ORNAMENTAL AND TURF MANUAL

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Ornamental and Turf
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CHAPTER I

USING PESTICIDES CORRECTLY

When application of a pesticide is necessary for control a particular pest, there are several points to consider before choosing the pesticide.

A. PESTICIDE PROPERTIES

1. Phytotoxicity causes undesirable injury to plants. Symptoms of phytotoxicity include leaf drop, stunting, overgrowth, discolored foliage, leaf curl, and stem distortion. The cause of phytotoxicity may be easy to determine or it may be subtle. Among the common causes of phytotoxicity are: pesticides, air pollutants, disease agents, insufficient moisture, improper fertilization, and other adverse growing conditions such as frost or excessive heat. Factors that may contribute to pesticide-caused phytotoxicity include: high air temperature during or immediately after application; excessive rates of pesticide; insufficient water; uneven distribution of the application; incompatibility of liquids or emulsifiable concentrates with wettable powders; mixing fertilizers with pesticide; and variety and species differences in tolerance of a pesticide.

2. Selectivity refers to a pesticide being more toxic to some species than to others. The mechanisms of selectivity, especially with herbicides, vary. Several methods to consider when applying a pesticide are:

   a. Differences in wetting properties.

   b. Waxy leaves will shed the pesticide more easily than a rough or pubescent leaf.

   c. Differences in plant root systems and the solubility and leaching ability of the pesticide. A shallow rooted weed may be controlled by a herbicide that does not leach from the upper soil surface leaving the deep rooted crop unaffected.

   d. True physiological tolerance to a particular pesticide. This physiological tolerance involves such things as the plant converting the pesticide to a nontoxic form or failing to translocate a herbicide within the plant.

For some pesticides, especially herbicides, more than one mechanism may be important. An understanding of the mechanism of selectivity of a particular pesticide can aid in the prevention and/or diagnosis of injury.

B. ENVIRONMENTAL CONCERNS

1. Pesticide movement in the environment can occur from drift, vaporization, runoff, leaching, wind erosion from treated surfaces and removal of treated foliage or litter. To minimize drift and vaporization, apply pesticides when winds are low, less than 10 MPH, and check first to make sure an inversion layer is not present. Use the lowest practical operating pressure and the largest practical nozzle opening. The nozzle must be kept as close to the target as possible without doing injury to the crop plant. Keep nozzles at the proper angle to reduce drift. When possible, select products with low volatility. Avoid using air blast sprayers and dusters when working near sensitive plants and areas inhabited by animals. Do not apply herbicides with air blast equipment.

Adverse effects of pesticide movement in the environment can be minimized by using the following tactics. Take special precautions when using pesticide on slopes to avoid runoff and wind erosion. Select the least hazardous pesticide that will do the job and use the lowest rate of application. If feasible, maintain a buffer zone between the areas to be treated and sensitive areas (play areas, gardens, lakes, or streams). Use mulches to help keep the pesticide in place. Consider the chances of heavy rainfall, and regulate the amount and duration of irrigation. Pesticides that leach into the subsoil may be more persistent because fewer soil organisms are present to break down the material. Be aware of the potential for groundwater contamination. Avoid carrying treated material or the pesticide residue from the target area to other areas.

2. Animals and people must be kept away from treated areas during application and until spray has dried, dust has settled, or the proper reentry time has been observed. Do not use pesticides when people or pets cannot be excluded before the reentry period. Keep animals and people away from areas of potential drift and runoff. Remove cars, toys, pet food dishes, barbecue grills, bird feeders, and other articles from the site before applying a pesticide. Windows and doors should be closed to keep pesticides from entering buildings.

3. Persistence of the pesticide that you apply is an important factor. Consider its effects in adjacent areas, on treated soil used to grow other plants, and effects on humans, pets, or other animals present after application. Repeated applications may cause harmful residues to accumulate.

4. Herbicide injury is a special problem. Some herbicides leave residues in the spray tank that will injure desirable plants. Use separate sprayers for herbicides. It is

important to remember that following label directions not only helps prevent plant injury, but also that failure to follow the label directions is illegal.

CHAPTER II

ORNAMENTAL INSECT PEST

A. INTRODUCTION

A commercial applicator is faced with a number of decisions when asked to control an arthropod pest (insects and mites) on ornamentals. First, it is important to realize that a variety of arthropod species utilize ornamentals for food and shelter. The applicator must be able to distinguish between the pest, natural enemies of the pest, and those which feed or utilize the plant for shelter but cause no appreciable damage to the plant. He must be able to determine if the arthropod, subjected to a control measure, is capable of causing the damage he sees or is described to him by a park attendant or homeowner. Is the arthropod presently in a stage of development in its life cycle which is susceptible to control? The proper answer to these questions will go a long way to satisfy customers, reduce environmental hazards, and eliminate the needless work and expense of reapplications. This manual, along with other reference material, will help the commercial applicator answer these questions.

Artifical classifications of insects are often difficult and confusing. One method classifies insects into two broad categories according to the number of life stages in a life cycle. Development from life stage to life stage usually results in a change in form termed "metamorphosis." There are two general types of metamorphosis, incomplete and complete. It is also important to remember that the insect must molt (shed it's external skeleton) to develop and grow within a life stage and between a life stage. Insects with incomplete metamorphosis have three life stages: 1) egg; 2) nymph (immature) and; 3) adult. Complete metamorphosis has four life stages: 1) egg; 2) larva (immature); 3) pupa (resting stage in which larval muscles, organs and tissues are broken down and replaced by adult forms; wings also develop during this stage) and; 4) adult. The order of insects with incomplete metamorphosis include: Orthoptera (grasshopppers, crickets, katydids), Demaptera (earwigs), Homoptera (aphids, scales mealybugs) and Hemiptera (true bugs). Insects orders with complete metamorphosis include: Lepidoptera (moths and butterflies), Coleoptera (beetles), Diptera (flies) and Hymenoptera (sawflies, bees and wasps).

A second method of classification used to facilitate the identification of an arthropod on ornamentals, is classification of the pest according to feeding damage. This manual is an introduction to the insect pests of ornamentals. Only one ornamental insect pest was selected from each order of insects and each type of feeding damage to illustrate a pest's biology. For further information consult the references at the end of this section.

Adequate control of an insect pest can only be obtained by applying a control during a susceptible life stage. The egg and pupal stages are insensitive to most chemical control procedures. For controls to be effective they should generally be initiated against the adults and immatures (nymphs and larvae). Sprays should be applied before the adults mate or the female lays eggs. Chemicals applied to control the immature stages should be applied while the larva or nymph is exposed on a leaf, tree trunk or fruit surface. Once the larva or nymph enters a rolled or tied leaf, gall, fruit, twig, branch or bark, controls are usually difficult to apply or ineffective. For more specific control recommendations see Table 1 on page 29.

B. TYPES OF INSECT FEEDING DAMAGE ON ORNAMENTALS

1. Defoliators

All defoliators have chewing mouthparts. Their feeding produces a distinct type of foliage damage.

Defoliation results in a reduction of photosynthesis due to leaf loss and interferes with the transpiration and transport of nutrients. Heavy defoliation weakens trees, shrubs and flowers often making them more susceptible to attack by other insects, diseases, or bad weather.

a. Insects which feed on entire leaf or stem

1) Grasshoppers (Crickets, Katydids) - Orthoptera

The order contains the grasshoppers, and other insects, such as crickets, and katydids which are generally not considered pests of ornamentals. A few are predators (insects which feed on other insects) which make them beneficial to humans.

The Order has three life stages per generation: the egg, the nymph, and the adult. The nymph resembles the adult but is smaller and its wings are not fully developed. All the insects in this order have chewing mouthparts. Both nymphs and adults will attack ornamentals. Movement by nymphs is restricted to jumping and thus are unable to move to a food source as readily as the adult.

There are over 100 species of grasshoppers in Montana but only three or four species could be considered pests of ornamentals. They are considered pests for two reasons: 1) They are general feeders, so are able to utilize several plant species for food; 2) Populations of the four species increase rapidly under ideal

developmental conditions and require a lot of food to sustain the population.

In large numbers grasshoppers can cause considerable damage. Plants attacked by grasshoppers may have large irregular holes in their leaves, or be missing leaves and stems. One or more of the species are capable of attacking almost all ornamentals and in out-break years they have been reported to even feed on evergreens.

2) Earwigs - Dermaptera

This order contains a species of earwigs which, when they reach high population numbers, can become a pest of vegetables, flowers and fruit. The earwigs in Montana are dark reddish brown with very short truncated front wings which meet straight down the back of the insect. The rounded hind-wings are folded under the front wings. At the tip of the insect's abdomen is a pair of sharp pincers, forcep-like structures, which are used to capture prey, to ward off predators, and occasionally to aid in folding the hind-wings under the fore-wings. The adult is approximately 4/5 in. (20 mm) long. Upon initial inspection it may be mistaken for a rove beetle. They are distinguished from rove beetles by the pincers.

Earwigs are general feeders utilizing plants, decaying matter and slow moving arthropods, such as snails and insect larvae. They may also feed on aphids in orchards and help keep their population in check. Young nymphs, which resemble the adult but lack fully developed wings, feed on green plant shoots eating holes in leaves of many different vegetables and flowers such as: dahlias, zinnias, hollyhocks, marigolds, lettuce, strawberries, celery, potatoes, sweet corn, and seedling beans and beets. The older nymphs and adults feed on the blossoms of many flowers, they may even climb fruit trees, especially apricots and peaches, to feed on ripening fruit.

The earwig is nocturnal, (active and feeds at night). For this reason the homeowner or gardener often sees the damage but rarely the culprit. During the day the earwig spends its time under rocks, boards, logs or other debris. To determine if earwigs have caused the damage, look for them in these areas or use a trap. The trap consists of rolled newspaper or a section of bamboo which the earwigs can utilize as a hiding place during the day. Shake the paper or bamboo out over a

bucket of water to dislodge and drown any earwigs which might be found in your trap.

3) Moths and Butterflies - Lepidoptera

This order is made up of butterflies and moths. Adult butterflies and moths have four membranous wings (a few females are wingless), the hindwings are slightly smaller than the forewings. The wings are generally covered with scales. The adult has sucking mouthparts which are in the form of a coiled tube. The adult is not a pest of ornamentals and turf but use its proboscis, coiled tube, to feed on the nectar of flowers. Some of the moths and butterflies, in the process of feeding, pollinate flowers and are considered quite beneficial. The larva, or caterpillar, is usually long and slender, has a well developed head with chewing mouthparts, three pairs of legs on the thorax and from two to five prolegs (psuedolegs) with hooks on the abdomen. It is the larval stage which can damage ornamentals. There is generally only one generation per year but a few, such as loopers, may have two to three generations.

Moths and butterflies can be difficult to distinguish. The characteristics listed below may aid in your identification:

MOTHS	BUTTERFLIES
antennae not knobbed at the tip	antennae thread-like, swollen or knobbed at the tip
wings usually a drab color	wings brightly colored
usually active at night or early morning and late evening	active during the day

Forest Tent Caterpillar:

The forest tent caterpillar (Malacosoma disstria Hubner) is one example of a moth pest. This insect is a native pest of forest, ornamental and fruit trees, and can be found throughout the United States. This caterpillar does not build a tent like many of the other closely related species. Instead, the caterpillars live in groups surrounded by a silken mat located on large limbs or tree trunks. They use silken threads to travel

from congregation areas to feeding sites in the tree canopy.

The mature larva is 1 1/2 to 2 in. long (36-50 mm), blue to black blue with black dots. The back of the larva has a row of buff colored diamond-shaped spots alternating with small white spots. The larva also has pale longitudinal yellow stripes and is sparsely covered with hairs. The moth is light buff brown with two oblique lines across the forewing and has a wingspan of 1 to 1 1/2 in. (24-38 mm).

The insect overwinters in the egg stage. Larvae start emerging in May and feed for approximately six weeks, reaching maturity in early June. The larvae will then spin white cocoons. The cocoons provide the insect protection while it pupates. The cocoon may be found within a leaf or attached to fences, bark, or ground objects. The adults emerge from the cocoon in 10 to 14 days. The female moth lays 200 eggs in a band around a twig or branch. There is only one generation per year.

The hosts of tent caterpillars are:

Preferred Host		Occasional Host		
Maple	Birch	Apple	Peach	Quince
Oak	Ash	Boxelder	Pear	Rose
Poplar		Cherry	Plum	Willow
		Hawthorne		Prune

4) Beetles - Coleoptera

This order contains the beetles. They are named for the hardened front wing of the adult which forms a sheath, or cover, over the back of the abdomen. The hindwing, which is membranous, is used for flight and is folded under the frontwing, or elytra. Beetles range in size from the very small, 1/32 in. (0.8 mm), to quite large, 3 in. (75 mm). The adult and larva have chewing mouthparts, so one or both can cause damage to ornamentals. Often the adult attacks one portion of the plant, such as the leaves, and the larva attacks another portion, such as the roots or bore into the stems. The shape of the larva is quite variable. The larva may be legless like the borers, C-shaped like the grubs, elongated like wireworms, or humpbacked like Colorado potato beetles. This makes identification of beetle larva a challenge. If your identification is

proving elusive, be sure to seek help from your County Extension Agent, Extension Entomologist or an Entomologist at the Montana Department of Agriculture.

5) Sawflies, bees, and wasps - Hymenoptera

The order Hymenoptera contains the bees, wasps, ants, parasitic wasps and sawflies. From a human standpoint this order is the most beneficial in the insect class. It contains the parasites and predators (insects which feed on or in other insects) of various insect pests. This order also contains a large portion of the plant pollinators. Sawflies are the most troublesome plant pest in this order.

The adult sawfly looks like a thick-waisted wasp often with a well developed ovipositor. The ovipositor is used to insert eggs into the tissue of its host plant. The ovipositor has not been modified for stinging as the in the case of the bees and wasps. The larva is generally the stage which damages plants. They may feed externally on plant foliage, or bore into stems, fruit, wood or leaves (leafminers). External feeders are often mistaken for the caterpillars of moths and butterflies. The following characteristics can be used to distinguish external feeding sawfly larvae from caterpillars:

a. sawfly larvae have more than five pairs of prolegs

b. prolegs lack hooks or crochets like caterpillars

c. sawfly larvae have only one pair of ocelli on the head.

Internal feeders may have the prolegs reduced or absent.

Sawflies usually have one generation per year, although a few tenthredinids, the common sawfly family, may have two or three. Most external and leafmining sawflies overwinter as full grown larvae or as pupa in a cocoon or protected cell in the soil. Boring species usually overwinter in a tunnel inside the host plant.

Cimbicid Sawflies:

The elm sawfly is in the family Cimbicidae. The adult sawfly is quite large, 3/4 to 1 in. (18-25 mm) long and has a wingspan of 1 1/2 to 1 3/4 in. (37-45 mm). The body is steel blue or black with four yellow spots on each side. The wings are a smokey color and the antennae are knobbed at the tip. The larva is wrinkled yellowish or greenish-white with a black median stripe and eight pairs of prolegs. Mature larvae are about 2 in. (50 mm) long. Females deposit eggs on leaves in May. Eggs hatch in June. The adults remain active through August feeding on the bark of twigs, especially in the tree tops. This feeding may result in girdling and killing the twigs. The larvae feed on leaves and in heavy infestations they may defoliate the tree.

Conifer Sawflies:

Adult Diprionidae range in size from a 1/4 to 1/2 in. (8-13 mm) in length. The antennae of the female is sawlike in shape while the male's appears feathery. The larvae, like other external feeding sawflies, have abdominal prolegs and are approximately 3/4 in. (18 mm) in length when mature. The larvae feed on old foliage which generally weakens the tree and slows growth. Rarely does it kill the tree. It poses a special threat when the sawfly is found feeding in conjunction with insects feeding on new foliage.

Common Sawflies:

Tenthredinidae is a very large family of sawflies (about 840 species in North America). The adults are medium to small rarely exceeding 1/2 in. (13 mm) in length. Adults are usually collected on foliage or flowers. The larvae of tenthredinids are variable in shape. External feeders are usually caterpillar-like in shape although a few, like the pear slug, are shaped like the name implies. Internal feeders (the leafminers and gall makers) usually have the pseudolegs, or prolegs, reduced or absent. Most of the larvae would not exceed 1/2 in. (13 mm) in length. There is usually only a single generation per year. These sawflies usually overwinter in a pupal cell or cocoon either in the ground or in a protected area.

Larch sawfly:

Pristiphora erichsonii (Hartig) is an example of an external feeding tenthredinid. This species of sawfly reproduces parthenogenetically (without mating with a male). The female lays the eggs in slits cut into young twigs in late May to early June. Oviposition or egg laying causes the young twig to twist or curl. Larvae emerge from the eggs and feed in groups of 40 to 50 usually attacking the lower branches of the tree first. The larvae overwinter in the ground as prepupae and there is only one generation per year. The larvae are dull gray green on their backs and pale underneath with black heads and legs. When mature they are approximately 5/8 in. (15 mm) in length. Adult females are approximately 3/8 in. (10 mm) in length and black with an orange band around the abdomen.

b. Leafrollers and leaftiers

Leafrollers are usually caterpillars (the larvae of moths and butterflies) or sawfly larvae which feed protected in a rolled leaf of their host plant. The feeding of these caterpillars cause the leaf to roll. On the other hand, leaftiers actually tie the margins of a leaf together with a silken thread. The rolled or tied leaf provides the larvae some protection from natural enemies and chemical sprays. Controls should be initiated before the insect begins to roll or tie leaves.

1. Fruit tree Leafroller:

The fruit tree leaf roller Archips argyrospilus (Walker) is found from coast to coast. The insect is a general feeder, attacking fruit trees as well as ornamentals such as ash, boxelder, elm, locust, poplar, willow and rose. The fruit tree leafroller overwinters in the egg stage in masses of 30 to 100 eggs plastered on twigs, branches, and tree trunks. The eggs are covered with a brown or gray varnish-like substance. The eggs hatch at the time apple buds separate in spring. Pale green larvae with brown heads crawl to feed in leaves, buds, and small fruits for about a month. They spin a light web around several leaves roll them together and continue to feed on the leaves. Fruit may also be included in the webbing. When fully grown, they are 3/4 in. (18 mm) in length. They pupate inside the folded leaves or on the trunk or branches of the tree. The brown moths with gold marking on their wings,

wing span 3/4 in. (18 mm), emerge in late June or July. There is one generation per year.

2. Web-spinning Sawflies:

Pamphiliids are usually less than 1/2 in. (12 mm) in length. The most economically damaging species is the Plum Webspinning Sawfly Neurotoma inconspicua (Norton).

The adult is black with red legs and 1/4 in. (6 mm) in length. Larvae are smooth grayish yellow and 3/4 in. (18 mm) in length at maturity. Eggs are laid in a leaf midrib in early spring. The larvae emerge and enclose the ends of the branches with webbing soon after the plum tree comes into full leaf. The larvae then feed on the leaves inside the web.

c. Skeletonizers:

Skeletonizers are usually the larvae of beetles, sawflies, and moths, which feed on only the more suceulent leaf tissues between the veins and midribs.

1. Cottonwood Leaf Beetle:

Larvae of Chrysomela scripta Fabricius are black, later turning a dirty yellow with black spots. The beetles have a dark brown head. The larva, when disturbed, emit a foul smelling milky fluid which repels predators. When the disturbance ceases, the larva retracts the droplet. The adult beetle is 1/4 in. (6 mm) in length, has a black head and thorax. The thorax is bordered in orange-red. The elytra are gold covered with a purplish line on their inner edge and seven purple-black spots.

The adults overwinter under bark, litter or forest debris often congregating under or near cottonwood or willow trees. Adults appear on the trees shortly after leaf emergence to feed and mate. Eggs are yellow or reddish in color and are deposited in clusters on the under surface of leaves. The eggs hatch in less than two weeks. When larvae first emerge from the egg, they feed in congregations but soon disperse. Larvae reach full size in two weeks. Mature larvae attach to the leaves in a head downward position and pupate. The adult emerges in two weeks. In Montana, there are usually two generations per year.

Larvae will skeletonize leaves of host trees, such as willow, poplar and cottonwood. Adults feed on leaves but cause little damage. Rarely do the beetles cause economic damage to the trees.

2. Pear Slugs

Caliroa cerasi (Linnaeus) (a sawfly) skeletonize the upper surfaces of leaves leaving only the veins and midrib. The lower surface of the leaf turns brown. The pear slug attacks cherry, plum, pear and occasionally hawthorne and mountain ash. There are two generations per year with the first occurring when the tree reaches the full leaf stage. The second generation attacks the trees in July or August. The sawflies overwinter in the soil as larvae. The adults are black and yellow, slightly larger than a housefly. Larvae are dark green to orange tadpole-like or slug-like in shape and covered with slime. When the larvae emerge they feed for two to three weeks and are 1/2 in. (13 mm) in length at maturity.

2. Sucking Insects

a. Rasping sucking:

1) Thrips - Thysanoptera

Thrips are minute, slender bodied insects 1/32 to 3/16 in. (0.8-5 mm) in length, just visible to the naked eye. The head appears square rather than rounded as in most other insects. Thrips may or may not have wings. If the four wings are present, they are long, narrow, and fringed with hair. Adults vary in color ranging from black, orange, lemon, to pale yellow. The insect uses its asymmetrical mouthparts to rasp or scrape the plant tissue and suck up the enclosed fluids. Thrips are capable of scarring fruit and foliage by their feeding. Plants subjected to heavy feeding by thrips often have a grayish or silverish cast. A few thrips species are capable of vectoring diseases such as tobacco ring spot virus. There are species of thrips which are beneficial acting as predators on plant eating thrips and insects.

Flower Thrips:

Frankliniella tritici (Fitch) have a very wide host range feeding on grasses, weeds, flowers, fruit and shade trees. It has a preference for grasses, legumes, roses, and peonies. Young

thrips are lemon-yellow, while the adults are amber or brownish yellow. The flower thrip is about 1/20 in. (1 mm) in length. This thrip injures flowers but does little damage to the foliage. Buds of roses damaged by thrips turn brown, petals often are stuck together or open only part way while blossoms are often distorted and the petals have brown edges. Thrips are generally found inside the petals often near their base. The life cycle may be completed in two weeks and there are several generations per year.

Banded Thrips:

Aeolothripidae are dark brown to yellow with three white bands on the wings. The Banded Thrip is often found in flower beds feeding on other thrips, aphids and mites. The larvae or nymphs are yellow shading to orange and also attack flower feeding arthropods.

b. Piercing sucking

1) True Bugs - Hemiptera

Two of the best distinguishing characteristics of true bugs are the structure of the front wing and the sucking mouthparts. The basal portion of the front wing (section closest to the body) is thickened or leathery while the apical portion (section furthest from the body) is membranous. This type of wing is termed a hemelytron or half leathery wing. The hind wings are entirely membranous. At rest, the wings are held flat over the abdomen with the membranous tips of the front wings overlapping. The mouthparts of true bugs form a slender segmented beak which is used to pierce plant tissue and suck up the enclosed fluids. The beak of true bugs and the closely related Homoptera, (aphids, scales, mealybugs) has two channels, a food and salivary channel. The salivary channel injects enzymes into the plant to help dissolve the contents of the plant cell and the food channel is used for ingestion (sucking up food).

The saliva can act as a toxin and cause further damage to the plant. A good example is chalky spot in lentils. The lygus bug feeds on the rapidly growing tissues in the developing lentil pod. Substances in the saliva disrupt the normal growth of the pod and distorts the seed lowering its market value.

True bugs also contain species which are beneficial feeding on insect pest, such as the Colorado potato beetle. It is important to identify insects before initiating control. It would be a shame to mistake a beneficial stink bug feeding on the Colorado potato beetle for a pest.

Tarnished Plant bug:

Lygus lineolaris (Palisot de Beauvois) can cause injury to a large number of economically important crops and ornamentals. A short list of ornamentals include; dahlias, asters, calendala, chrysanthemums, gladiolus, marigold, sunflower, verbena, zinnia, etc. The tarnished plant bug will also attack vegetables and fruits.

Toxin in the saliva will deform beets and chard leaves. Peaches may be dwarfed and pitted and dahlia buds may die or the flowers may be distorted.

Adults are small, 1/4 in. (8 mm) in length, flattened, oval, irregularly mottled with white, yellow, and black blotches on the front wing. There is a clear yellow triangle marked with a black dot on the lower third of each front wing. Adults hibernate among weeds, tender leaves, stones or bark. In early spring the adults suck out the buds of fruit trees for food. After feeding on fruit trees, they migrate to the leaves and flowers of other plants to lay eggs. Emerging nymphs are very small, greenish yellow, marked with four black dots on the thorax and one on the abdomen. The life cycle requires three to four weeks and there may be three to five generations a season.

2) Aphids, Scales, Mealybugs - Homoptera

Cicadas, pysllids, whiteflies, aphids, scales, mealybugs leaf, tree, plant and frog-hoppers.

This order contains a large and diverse group of insects. All the insects in this order are plant feeders and many can be a problem on ornamentals. There are also a few species which transmit plant diseases. The Homoptera use their piercing-sucking mouthparts to pierce plant tissue and suck up the fluid of plant cells. The mouthparts of Homoptera are shaped like a beak which appears to arise from the back of the head instead of the front as in the true bugs. The front wings are uniform in structure either

membranous or slightly thickened, unlike the hemelytra of true bugs. The wings are usually held roof-like over the body. The insects in this order have three life stages per generation: eggs, nymphs, and adults.

Froghoppers or Spittlebugs:

Cercopidea are small hopping insects, 1/16 to 3/8 in. (2-10 mm) in length, they may resemble tiny frogs in shape. They are usually brown or gray in color. Many resemble leafhoppers but the body of froghoppers is usually more oval or less parallel sided than leafhoppers. Froghoppers feed on shrubs, weeds, grasses, and flowers. The nymphs (immatures) which are called spittlebugs surround themselves with a frothy spittle while feeding on plants. Most species of froghoppers cause little feeding damage to plants. A few species attack pines and can become a pest at high population levels.

Leafhopper:

Cicadellidae may range in size 1/16 to 1/2 in. (2-13 mm) and vary in form, color, and size. Leafhoppers occur in almost all types of plants including forest, shade, orchard tree, shrubs, grasses, flowers, and garden crops. They feed principally on the leaves of their host. The bulk of the leafhopper species have a single generation per year a few may have two or three. There are many economically important pest species in this insect family.

Leafhoppers can cause five major types of injury to plants:

a) Reduce the sap and destroy chlorophyll in leaves. Damage appears as minute white or yellow spots on the leaf or stem, with continued feeding, leaves turn yellow or brown.

b) Feeding plugs food and water transport vessels in plant, impairing nutrient transfer.

c) Eggs laid in green twigs, will cause the terminal portion to die.

d) Transmit plant diseases.

e) Stunting and leaf curling because feeding inhibits the growth of the undersurface of a leaf.

Aster, or Six-spotted, Leafhoppers:

Macrosteles fascifrons (Stail) is an important garden and ornamental pest because of its ability to transmit a disease known as aster yellows. This disease will infect asters, chrysanthemums, petunias, phlox, sweet williams, lettuce, celery, carrot, parsley, alfalfa, and grain crops. Damage symptoms include general yellowing of foliage, clearing of affected veins and the plant may appear stunted and distorted with excessive branching.

This leafhopper is greenish yellow with six black spots. It overwinters as an egg on perennial weeds or flowers. Nymphs emerge in the spring to feed on weeds and flowers. The nymphs do not vector the disease because it takes 10 to 18 days for the mycoplasma to incubate in the leafhopper and become infective. The nymphs molt more rapidly than this, resulting in loss of the innoculum before it becomes infective. Nymphs emerge as adults in approximately 20 days.

Jumping Plantlice:

Psyllids are small. 1/16 to 3/16 in. (2-5 mm) in length and usually resemble very tiny cicadas. The psyllids have strong jumping hindlegs and relatively long antennae. The adults of both sexes are winged. Nymphs of many species secrete a large amount of white waxy material around their bodies which make them superficially resemble woolly aphids.

Pear psylla:

Psylla pyricola Foerster is a pest of pears. The insect produces large amounts of honeydew which covers the foliage and fruit. The honeydew provides a good growth medium for sooty mold. The mold produces brown spots on leaves, scars and blackens the fruit.

The adult pear psylla is dark reddish brown and 1/10 in. (1 mm) in length. Adults overwinter in bark crevices, or under leaves on the ground. In early spring females lay pear shaped yellow eggs around new buds. In two weeks the eggs hatch into wingless nymphs 1/80 in. (0.25 mm) in length. In

a month the nymphs reach maturity and the adults emerge. Nymphs resemble the adult but lack wings. There are three to five generations per year. The pear psyllid is also capable of vectoring a virus of pears.

Aphids (Plantlice):

Aphididae are small, soft bodied insects, about 1/8 to 1/4 in. (3-6 mm) in length, frequently found in large numbers sucking the sap from the stems and leaves of plants. Aphids are pear-like in body shape with a pair of cornicles (tiny tube-like structures) on the posterior end of the abdomen. The cornicles are used to secrete defensive fluids. An aphid, when winged, holds the wing vertically (roof-like) above the body. Some of the aphid species (i.e. the woolly apple aphid) cover their bodies with a white waxy material. Aphids also excrete honeydew from the anus. Honeydew is made up of excess plant sap (sugar and waste materials) ingested by the insect. Large quantities of honeydew, because of its sticky nature, can be a nuisance when it adheres to leaves, fruit and automobiles. Ants utilize honeydew as food. To insure an adequate supply of honeydew, ants will often protect the aphid from natural enemies and tend the aphids like cows, moving them from plant to plant when the ants food supply declines.

Aphids have a unique and complex life cycle. Most species overwinter in the egg stage. The nymphs emerge from the eggs in spring and then develop into wingless female adults which reproduce without mating. In the spring one to two generations of aphids may be produced on the primary host.

Later in the spring or summer, due to a decline in food quality or crowding, the wingless females produce winged females which seek a new, secondary host. Several generations of wingless female adults may be produced on the secondary host. In the late summer or early fall another winged female generation is produced and these females return to the original or primary host and reproduce sexually. These females lay the overwintering eggs on the primary host.

Aphids can build up a large population using this form of reproduction. The population is usually kept in check by parasites, and predators, (parasitic wasp ladybird beetles, lacewings, and

syrphid larvae). The feeding of aphids causes curling or wilting and they also serve as plant disease vectors.

Green Peach Aphid:

Myzus persicae (Sulzer) is an introduced pest from Europe, it is now distributed throughout the United States. The green peach aphid has a wide host range attacking as many as 200 different kinds of plants. The green peach aphid also vectors such diseases as tomato and tobacco mosaic, beet yellows, and leaf roll of potatoes, just to name a few.

Females lay overwintering, shining black eggs on the bark and buds of fruit trees in the genus Prunus (peaches, plums, apricots, etc). In spring the pale yellowish green nymphs emerge from the eggs and develop into adults. Two to three generations of wingless females are produced without mating (asexually) on the overwintering primary host. In the next stage of population development, winged migrants are produced which seek new secondary hosts, such as a weed or garden plant. Several wingless generations may develop on this host. In autumn winged females develop and return to peach, apricot or plum trees. This migrant will give birth to males and females which will mate, followed by egg deposition on the winter host.

Scales and Mealybugs:

Coccoidea and Psuedococcidae constitute a very large group of plant feeders. The male is very small 1/16 in. (1 mm), midge or gnat-like, with only one pair of wings on the middle thoracic segment. The males also lack a beak, so are unable to feed. The abdomen has one terminal style-like process. The female is wingless and legless 1/4 in. (6 mm), and usually has a waxy, cottony or scale-like protective covering. Eggs are laid under the protective cover. The first instar nymphs, stage which emerges from the egg, has legs and are fairly active. For this reason this stage is called a crawler. After the first molt the legs and antennae are often lost, the insect becomes sessile, and secretes a covering over the body. The female nymphs remain under the protective covering. The males pupate, enter a resting stage and continue to feed, which allows time for wings to develop. The adult male uses the wings to locate a female, they mate and the

female lays eggs under the protective covering. Eggs hatch and the nymphs leave the cover as crawlers. Females may also produce young asexually, without mating.

Oystershell scales:

Lepidosaphes ulmi (Linnaeus) attack broadleaf trees and shrubs. Female scales under their protective cover look like oysters encrusted on a tree trunk, limb, or twig. There are three color races.

The gray race is found on lilac, beech, maple, willow and many ornamentals. The scales are 1/8 in. (3 mm) in length by 1/16 in. (1 mm) in width. The scale broadens in width at the posterior end, curves slightly and has many parallel cross ridges. There is one generation per year.

The brown race is common on fruits, attacking apples, apricots, pears, plums, grapes, raspberries, dogwood, lilac, mountain ash, etc. Old scales are nearly black. There are two generations per year.

The yellow-brown race has a yellow fringe on the rear portion of the scale. It is common on birch and poplar trees. This race has a second generation in late July. Other plants attacked by this scale include alder, aspen, peony, cotoneaster, elm, hackberry, honeysuckle, oak and spirea.

3. Leafminers

Leafminers are the larvae of certain moths, sawflies and flies which feed between the upper and lower surface of leaves. The damage may appear as a blister, blotch, or a serpentine tunnel.

Leafmining moths:

Caterpillars which mine leaves often lack well developed prolegs and may be difficult to distinguish from insects in other orders which mine leaves. Sawflies and moth leafminers will be the most difficult to distinguish. One character which is usually helpful are the number of simple eyes or ocelli. Caterpillars usually have more than one pair of ocelli while sawfly larvae have none or only one pair.

Lilac leafminer

Caloptilia syringella (Fabricuis) is a European moth introduced into the U.S. in 1925. The larvae mine the leaves of lilac, privit and have also been reported on ash. The moth is brownish in color with six yellow lines on the forewings. The moths emerge from cocoons in May and again in July. Females lay eggs in the axils of veins on the underside of the leaves. The pale yellow larvae, 1/3 in. (8 mm) in length first mine and then roll and skeletonize the leaves. The second generation overwinters in cocoons as pupae. There are two generation per year.

4. Flies - Diptera

This order contains the flies, which include 16,000 North American species. Adult flies have only one pair of wings located on the second segment of the thorax (mesothorax). The second pair are reduced to small knobbed structures called halteres, which function as organs of equilibrium while the fly is in flight. The single pair of wings plus the halteres provide the best character for separating flies from other orders of insects. The only other insects which have one pair of wings and halteres are the male scale insects. Male scales are much smaller than the majority of flies.

The larvae are usually legless and worm-like, often lacking a well developed head. A larva is commonly termed a maggot. Flies exploit may different habitats, including fruits as in the case of the apple maggot in hawthorn, the developing ovaries of ornamental flowers leaves and stems (leafminers and gall makers), and roots (seed corn and onion maggot).

Leafmining flies:

Another family of flies (Agromyzidae) which attack ornamentals are the leafminer flies. The adult leafminer fly is small, 1/8 in. (3 mm) in length. The body of the fly can be black, yellow or black with yellow. The wings are clear. The female lays the eggs in the leaves of flowers (as in the case of the Columbine leafminer Phytomyza aquilegivora (Spencer) or a few species may lay their eggs on the leaves of trees Catalpa leafminer Phytobia clara (Melander). The larva hatch from the egg and feed between the upper and lower layer of a leaf.

5. Gall Forming Insects and Mites

The adult female while laying eggs or the larva or nymph while feeding, releases a chemical into the plant tissue which causes the cells to grow and expand rapidly. The tissues eventually surround the larva or nymph providing them with a protected area to feed.

a. Gall Midges

The gall midges, another fly family, (Cecidomyiidae) can also damage ornamentals. Gall midges are minute, delicate flies with long legs, relatively long antennae and reduced wing venation, may appear like tiny mosquitoes. Larvae of about two-thirds of the North American species of gall midges produce galls on plants. Larvae of gall midges are tiny maggots, with small, poorly developed head and mouthparts. In the last larval stage, most species have a ±T' shaped sclerite called "the breast bone" on the ventral side of the first segment of the thorax. Many larvae are brightly colored - red, orange, pink or yellow. The eggs are laid on the leaves or new shoots of flowers. The larva hatch from the egg and bore into the plant tissue. Larval feeding stimulates the growth of plant tissue which forms the gall around the larva. The larva may pupate in the gall or in the soil. The number of generations per year varies in this family from one to several.

b. Cone Scale Midge

Contarinia pseudotsugae Condraskoff emerges from the soil in early May. Several eggs are laid on the needles. The eggs hatch and small yellowish larvae emerge to feed on the needles. Larval feeding results in the formation of a small gall on the needle. In late fall and early winter the larvae drop to the ground to overwinter (diapause) Pupae develop in spring. Heavy infestations lead to foliage drop and sometimes to the death of twigs. This midge can be a significant pest of Christmas trees.

c. Gall forming sawflies

Willow leaf gall sawfly

Pontania spp. adults emerge from the ground as the leaves begin to develop. Females lay eggs on the leaves. Larvae emerge from the eggs and begin feeding on the leaf, their feeding stimulates the formation of a gall. The fully developed gall is red and hemispherical in shape. When the larvae reach maturity they molt to the prepupal stage. The prepupa perforates the gall and drops to the ground spinning a cocoon among the plant debris or in the soil. The sawfly will either overwinter in this stage or emerge to start a second or third generation.

The whole life cycle may last from 38 to 44 days. The adult sawfly is black with yellowish or light brown areas about 1/8 in. (4 mm) in length. The legs are

reddish brown in color. The larva is creamy yellow, sometimes with a light greenish tinge. The head is light brown. At maturity the larva is 1/4 in. (8 mm) in length.

d. Gall forming psyllids

The Hackberry Nipplegall Psyllids are members of the genus Pachypsylla. This particular insect is pale to dark reddish brown and similar in appearance to all other psyllids. The feeding of the nymph causes the formation of globular hairy galls on the underside of the leaf and crater-like depression on the upper surface.

e. Gall forming aphids

Poplar Petiole Stem Gall Aphid:

Pemphigus populitransversus Riley has rudimentary ring-like cornicles, but in other characteristics resembles free living aphids. This aphid overwinters in irregular shaped galls on the petiole of poplar, cottonwood and aspen leaves. In summer, winged forms migrate to an alternate host such as beets, curly dock, lettuce or dandelions.

Cooley Spruce Gall Adelgid:

Adelges cooleyi (Gillette) is an aphid-like insect which is responsible for the formation of pineapple shaped galls on the twigs of spruce. The overwintering female stage of the adelgid attacks Douglas fir. The female appears as a small, cottony tuft on the underside of Douglas fir needles. Feeding, by this insect, causes yellow spots on the needles. Frequently damage leads to the browning and premature shedding of foliage. Winged females are produced in spring, migrate to spruce, laying their eggs at the base of needles. The young hatch and begin to feed at the base of needles. The feeding of the adelgid cause the formation of a cone-shaped gall.

f. Eriophyid mites

Eriophyid mites cause gall formation on plants. This group of mites is quite small, often 0.2 mm in length (1 mm is slightly larger than 1/32 in.). A female initiates the formation of a gall through feeding or by releasing chemicals into the food while feeding. The female lays her eggs within the gall. Nymphs hatch and begin to feed, their feeding contributes to further gall expansion. The immature mites pass through two nymphal stages before becoming adults. Growth from egg

to adult may take only two weeks. Adult females often hibernate in bark fissures and the scales of buds. In spring and early summer, the adult female emerges to infest new leaves, flowers, and fruits. Eriophyid mites initiate several types of galls. The galls are described as flower, bud, leaf roll, pouch or pocket galls. Galls of eriophyid mites are commonly found on the leaves of alder, willow, poison oak, bitter cherry, chokecherry, sierra plum, walnut and maple.

6. Boring Insects

There are larvae in the order Lepidoptera, moths and butterflies, Coleoptera, beetles, and a few Hymenoptera, the sawflies, which bore into the wood and cause damage to conifers, evergreens, and deciduous trees and shrubs. Some of the borers attack the sapwood while others tunnel into heartwood. Boring insects generally attack stressed trees which have been weakened or injured by drought, mechanical injury, transplant shocks, defoliation by leaf feeding insects and mites, chemical injury etc.

Attack by boring insects can be minimized by following some preventative measures:

a. Trees should be adequately watered,

b. The root system of a tree should not be crowded by such things as concrete walks, driveways or patios,

c. Mechanical injury to a young tree can be minimized by wrapping the trunk,

d. Prune away dead branches and treat cuts with wound dressing.

1) Wood Boring Beetles

Adult beetles have the hardened front wings which form a sheath over the back of the abdomen. Larvae which bore in wood are often termed grubs because they are whitish in color, have a fleshy body and are legless. The head capsule is the only hardend and darkened area on the body of a larvae. Adults and larvae have chewing mouthparts.

Bronze Birch Borer:

Agrilus anxius Gory is distributed through the northern United States as far west as Idaho. This beetle attacks birches, while closely related species attck poplar, quacking aspen, cottonwood and willows. It is more injurious to weakened

trees and trees grown in the open than to forest trees.

Adult beetles emerge in late May or early June, mate, and the female deposits eggs in the crevices of bark. Larvae hatch and tunnel just under the bark. Their tunnelling causes the bark to lossen from the tree. Die back of tree tops is the first sign of injury. The beetle larva is white and legless with a darkened head. Behind the head is an enlarged flattened area. This enlarged area combined with the elongated body makes the larva look alot like a horseshoe or square headed nail. The larva has been given the common name of flatheaded wood borer because of this peculiar shape. The larva when mature is approximately 1 in. (25 mm) in length. There is one generation per year. The adult is slender olive-bronze, with a blunt head and tapering body. The pronotum (first segment of the thorax) wraps around the back of the head so that the beetle looks like it is wearing a turtle neck sweater. The adult is 3/8 to 1/2 in. (9-13 mm) in length.

2) Wood boring moths

Adults moths have four wings covered with scales and curled probocsis used to suck up plant nector. The larvae or caterpillars have a darkened and hardened head capsule followed by an elongate trunk with three pair of thoracic legs and up to five pair of prolegs with hooks on the abdomen.

Carpenterworm

Prionoxystus robiniae (Peck) is widely distrubted throughout the U.S. The larvae or catepillars attack many shade trees, such as ash, elm, locust, maple, oak poplar, willow, and sometimes apricot and pears. One life cycle may take three years. The larvae hatch and begin feeding on the solid wood. The larvae feed on the sapewood while young, as they mature they continue to bore into and feed on the heartwood. The tunnels made by larval feeding may be as large as an inch in diameter. The borer is white, tinted with rose, with small brown tubercles over the body. The head is dark brown. At maturity the caterpillar or larva is 1 to 2-1/2 in. (25-63 mm) in length. Moths emerge in June and July, mate, and lay greenish-white sticky eggs in bark crevices, wounds, and old burrows. The adult moth has a wingspan of 2-1/2 to 3 in. (60-75 mm). The forewings are molted gray while the smaller

hindwings are a smokey color. The body of the insect is very stout in appearance. The male is smaller with an orange margin on its hindwings.

3) Wood boring sawflies

Only the horntails bore in live wood. The larvae may burrow in maple, elm, and beech, however, are rarely numerous enough to cause a great deal of damge. Larvae resemble a caterpillar with reduced or no prolegs and have one prong on the end of the abdomen. Adults look like thick waisted wasps with a long tail at the end of the abdomen. The tail looks like an ominous stinger but is used only to lay eggs.

4) Bark beetles

Bark beetles are tiny insects which tunnel under the bark and into the outer wood surface of trees. Beetle larvae generally attack weakened or dying trees. Some of the bark beetles such as the lesser European elm bark beetle, also transmit a fungal disease, (Dutch elm disease) when they attack. The disease hastens the death of the tree.

Mountain pine beetles

Dendroctonus ponderosae Hopkins emerge during July and August, fly to weakened trees, bore through the bark into the outer wood layer where they excavate egg galleries. The pearly white eggs are laid individually along the sides of the gallery. Larvae feed on the bark during winter, reaching maturity in early summer. There is one generation per year.

Mature larvae are yellowish-white legless grubs with dark heads. The larvae are approximately 1/4 in. (8 mm) in length. The adult is a cylinderical stout bodied beetle, brown to black in color and 1/8 to 1/4 in. (4-8 mm) in length.

7. Mites

Mites are arthropods like the insects but belong to the animal class Arachnida (spiders and ticks) rather than Insecta. External characters which can be used to separate mites from insects include:

Mites	Insects
1. Two body regions Head and thorax joined, abdomen	1. Three body regions head - thorax - abdomen
2. no antennae	2. pair of antennae
3. eight legs (nymphs have six)	3. six legs
4. simple eyes	4. compound eyes

The mites are more closely related to spiders, ticks, scorpions and daddy-longlegs, but are much smaller. A large mite might be 1/32 in. (0.75 mm). Mites use their stylet-like mouthparts to pierce plant cells, the cell contents ooze from the hole and the mite laps it up. Mites us the wind or ride on insects and birds, which come in contact with the host plants to travel distances exceeding movement from leaf to leaf.

Spider mites:

Tetranychus urticae Koch has been recorded on more than 150 plants. Almost all greenhouse plants are subject to infestations. Two spotted spider mites overwinter in the ground, under leaves, and in cracks and crevices. Activity begins early in spring when temperatures exceed 54 degrees F. and development is arrested when temperatures exceed 104 degrees F. Optimum development temperatures range from 85 to 90 degrees F. At these temperatures the spider mite can complete a life cycle in 8 to 12 days.

Females have a life span of 30 days and are capable of laying an average of 100 eggs during this period. Young six-legged nymphs emerge from the egg and feed for a day or two. Nymphs enter a resting stage, and molt to a second active stage and feed. They then enter a second resting stage and molt to a third time before becoming adult females. Males pass through only two stages. Eggs from unfertilized females become males. Mites spin webs which are used to move along the leaf surface and from one leaf to another. Feeding, egg laying, and development of nymphs and adults occurs under the webbing.

Female spider mites are less than 1/50 in. (0.50 mm), males and nymphs are smaller. The bodies are oval, yellow or greenish with two dark spots on the back.

Detecting spider mites can be accomplished by looking for their webbing on the leaves of plants or feeding damage. Under moderate feeding pressure leaves or portions of leaves will yellow, while under heavy feeding the leaf will turn

brown. Detection using the above methods usually means the spider mite population is quite high and highly prized or valued ornamentals may have already lost their aesthetic value. Early detection requires careful inspection of the top and bottom of leaf surfaces for mites and webbing with a magnifying lens.

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Insect	Biology	Damaging Stage and Host	Controls	
			Non-Chemical	Chemical
Grasshoppers	Page 5	Nymph and adult general feeders attack most garden crops, ornamental shrubs, even reported feeding on evergreens in outbreak years.	Nosema locustae Fall tillage discourages egg laying Protect a few plants by a covering of cheese cloth Grasshoppers like dry hot climate, light continous mist over plants susceptible to attack may discourage grasshoppers. Replace weedy margins with perennial grasses. Green succulent plant (act as a trap crop) around garden or yard grasshoppers controlled in this area before they reach garden or ornamentals.	Carbaryl Malathion Diazinon Clorpyrifos (only around gardens)
Earwigs (occasional pest usually beneficial)	Page 6	Nymph and adult general feeder ususally flowers.	Trap can be designed using a section of bamboo or rolled newspaper, areas used for hiding during day. Shake trap over bucket of water to drown earwigs. Earwigs like damp cool places if possible reduce lawn and flower watering. Remove hiding places near garden and flowers, such as mulch, compost and wood piles. Keep grass and weeds short around garden and flowers.	Carbaryl (garden) Diazinon Chlorpyrifos Baygon

Insect	Biology	Damaging Stage and Host	Controls	
			Non-Chemical	Chemical
Forest Tent Caterpillar	Page 7	Larva (caterpillar) maple, oak, poplar, birch, ash, hawthorne, boxelder, willow, rose.	Prune away infested branches before eggs hatch at night or cool moist cloudy days prune away areas where caterpillars congregate (as long as congregation sites are not on the trunk or large branches of tree) May be able to collect larvae and silken mat by rolling up the mass on a stick with nails on the end. Burn larvae and webbing.	(only recommended when trees are experiencing a lot of defoliation) Methoxychlor Dipel Thuricide (Bacillus thuringiensis) bacteria effective against pest apply when caterpillars are small Carbaryl Malathion Clorpyrifos Acephate Diazinon
Fruit tree leafroller	Page 11	Larvae (caterpillar) apricot, cherry, currant, pear, plum, ash, boxelder, elm, locust, poplar, willow.	Monitor population using pheromone trap. Remove infested leaves (if attack not too heavy) dispose in a trash bag or burn.	Dipel (B.t.) Thuricide (B.t.) (B.t. = Bacillus thuringiensis Carbaryl Diazinon Delayed Dormant Spray Endosulfan. Controls initiated before larvae roll leaves.

Insect	Biology	Damaging Stage and Host	Controls	
			Non-Chemical	Chemical
Cottonwood leaf beetle (Aspen leaf beetle close relative)	Page 12	Adults and larva Willow, cottonwood, poplar, aspen.	Not much, may try to disrupt overwintering sites under trees, raking and picking up leaves may help.	Endosulfan Acephate (rarely a serious pest)
Plum Webspinning Sawfly	Page 12	Larva Plums, sand cherries.	-	-
Elm Sawfly	Page 10	Larva and adult Elm, willow, poplar, alder, maple.	-	-
Conifer sawflies Neodiprion spp.	Page 10	Larvae Douglas-fir, balsam fir, spruce, lodge pole, ponderasa pine.	Many natural enemies	Aerial spraying in forest setting none registered in ornamentals.
Larch sawfly	Page 11	Larvae (may cause twig to curl) larch.	Parasite has been released shows promise.	-
Pear slug (Sawfly)	Page 13	Larvae Cherry,plum, pear occasionally hawthorne, mountain ash.	Shallow cultivation in spring or fall (no deeper than 2" wood ashes dusted on tree will dry out larvae.	Diazinon Insecticidal Soap
Flower thrips	Page 13	Nymph and adult Alfalfa, vetch, clover, weeds, roses, peonies other flowers.	Proper id important may be controlled by predator thrips (see page 14) Remove infested flowers and buds. Proper watering, water stressed plants, particularly vulnerable. Remove weeds and volunteer plants to eliminate harborages.	Insecticidal Soap Dimethoate (roses) Malathion Diazinon Acephate (ornamentals)

Insect	Biology	Damaging Stage and Host	Controls	
			Non-Chemical	Chemical
Tarnished plant bug	Page 15	Nymph and adult dahlias, asters, chrysanthemums, gladiolus, marigold, sunflower, zinnia, vegetables and fruits.	Sanitation Keep garden and ornamentals free of weeds.	Carbaryl Malathion
Froghoppers	Page 16	not a pest.		
Aster leafhopper (six spotted)	Page 17	Adult and nymph vectors a disease aster yellows asters, phlox, petunias, chrysanthemums, sweet williams, lettuce, celery, carrot, parsley, alfalfa and grains.		Methoxychlor Chlorpyrifos Acephate Carbaryl Dimethoate
Pear Psylla	Page 17	pears, (may vector a pear virus).		Dormant oil in early spring kills eggs and adults (just before buds swell) Endosulfan

Insect	Biology	Damaging Stage and Host	Controls	
			Non-Chemical	Chemical
Green peach aphid	Page 19	Nymphs and adults Over 200 plants.	Aphids attracted to color, yellow; make traps using a yellow dish pan filled with slightly soapy water, will attract and drown aphids. Paint plywood bright yellow and coat with an adhesive like tanglefoot. Aluminum foil mulch under plants confuses aphids. Keep ants off plants, they will protect aphids from their natural enemies, (use a sticky band around trees or plants to keep ants away from aphids)	Endosulfan Malathion Insecticidal soap Diazinon
Oystershell scales	Page 20	Nymphs and adults Lilac, beech, maple, willow, apple, apricot, pear, plum, mountain ash, birch, poplar, hackberry, boxelder.	Dormant oil sprays sufficate eggs	Late dormant or delayed sprays Diazinon Pydrin Summer sprays directed toward crawlers which appear in June or early July and again in early September.
Two spotted spider mite	Page 27	Nymphs and adults garden plants, fruit trees, flowers, ornamental trees, general feeder.	Release of predatory mites	Kelthane malathion Acephate Meta Systox

Insect	Biology	Damaging Stage and Host	Controls	
			Non-Chemical	Chemical
Lilac leafminer	Page 20	Larvae or caterpillars Lilac and privet	Remove infested leaves and burn, prune back leaves, leaving healthy growth.	Diazinon Acephate Insecticide (soap in July applied to larval stage before entering mine in leaf)
Columbine leafminer	Page 21	Larva Columbine and aster	Pick off infested leaves and destory.	Malathion Spray before insects enters leaf applied to larval stage before entering mine in leaf.
Willow leaf gall sawfly	Page 22	Larvae Willow	Usually leaves unsightly but does not hurt tree.	Acephate Malathion Diazinon Spray directed at adults or larvae before gall forms. Once in galls larvae immune to spray.
Hackberry Nipple Gall Psyllid	Page 23	Nymph and adult	-	-
Poplar Petrole Stem Gall Aphid	Page 23	Nymph and adults Poplar, cottonwood and aspen, lettuce, beets, turnips and weed roots.	Galls not particularly hazardous to tree. On isolated trees pick and destroy galls	Acephate apply to foliage in early spring before gall reaction becomes widespread.

Insect	Biology	Damaging Stage and Host	Controls	
			Non-Chemical	Chemical
Cooley Spruce Gall Adelgid	Page 23	Nymph and adult Douglas fir, spruce.	Pick and destroy galls on spruce.	Endosulfan Carbaryl applied before gall formation in early spring.
Eriophyid Mites	Page 23	Nymphs and adults many hosts.	Remove and destroy galls when possible. Dormant oil	Dormant spray delayed dormant sprays applied as winter buds swell help reduce population Late spring and summer or post harvest sprays carbaryl Endosulfan Systox
Bronze Birch Borer	Page 24	Larvae Poplar, quacking aspen, cottonwood, willows.	Vigorously growing trees less susceptible to attack. Infestation detected prune away branches before adults emerge in May.	Clorpyrifos Dimethoate When temperature below 80 degrees F.
Carpenterworm	Page 25	Larvae Ash, elm, locust, maple, oak, poplar, willow.	Cut and destroy dead and dying branches. Keep wounds painted to prevent secondary infection.	Nothing registered
Mountain Pine beetle	Page 26	Larvae look for fine wood dust in the bark	Attack stress trees. Cut down damaged trees and burn them. Keep trees healthy with adequate fertilizer and water. Aggregation pheromones used to monitor populations and disrupt beetles ability to find distressed trees.	Carbaryl

CHAPTER III

ORNAMENTAL WEED MANAGEMENT

Ornamental plants include shade trees, shrubs, herbaceous annuals and perennials, bulbs, and nonturf ground covers. Given this variety of plant species, a selective weed control program is difficult to develop. Weeds in a landscape situation reduce yield, impair human health and detract from the beauty of the landscape. Careful management of both landscape plants and weeds is essential to minimize control effects on nontarget plants.

A. WEED LIFE CYCLES

1. Annual weeds are most troublesome in intensively cultivated ornamentals. Annual weeds germinate either in the fall (winter annuals) or in the early spring (summer annuals) and grow, flower, set seed and die within a one year period. Prevention of seed production is the only effective control.

Common annual weeds found in ornamental plantings include:

a. grasses which germinate during the spring and summer (crabgrass, foxtail, fall panicum, barn yard grass);

b. grasses which germinate during the late summer or fall (annual bluegrass, annual brome grass);

c. broadleafed weeds which germinate during the warm season and are killed by hard frost (purslane, pigweed, lambsquarter); and

d. broadleafed weeds that survive freezing temperatures (horseweed, common chickweed, bittercress, pepperweed).

2. Biennial and perennial weeds are most troublesome in uncultivated ornamentals. Biennial weeds complete their life cycle in two years, overwintering as a low growing rosette and flowering setting seed and dying the second year. Biennials are controlled most effectively in the seedling or rosette stage. Fall and early spring treatments are often effective.

Perennial weeds have underground plant parts (bulbs, rhizomes, creeping rootstock) and survive from year to year. Simple perennials, such as dandelions, produce seeds and produce new plants from the crown area of the plant. Creeping perennials produce new plants vegetatively by underground creeping roots or rhizomes. They are spread readily by the dispersal of seeds and by the movement of seeds and vegetation parts in soil, water, root balls,

cultivating equipment and wind. Long-term control must be aimed at eradication of the overwintering plant parts.

Common biennial and perennial weeds found in ornamental plantings include: quackgrass, Canada thistle, bindweed, dandelion, nutsedge, and some woody plants.

B. CONTROL METHODS

Weed control methods in ornamentals include handweeding, mulching, cultivation and herbicides. Both target weeds and ornamental plants must be considered when choosing a control method. All weed control methods should be used in combination with other crop and soil management practices, including optimum planting (rate and timing), quality weed free seeds or plants, optimum soil fertility and good water management.

1. Hand weeding is useful in situations where ornamental plantings are highly valuable and sensitive plants cannot tolerate injury. It is a tedious control method and often too expensive for use in professional situations. It is most effective in small areas and home gardens.

2. Mulches are commonly used quite effectively. To control annual weeds a mulch 2 to 3 inches thick is sufficient. Good mulching material includes wood or bark chips, sawdust, peatmoss, small grain straw, pine needles, gravel or stones. An ideal mulch allows free passage of moisture and air, but smothers growth of young weed seeds and prevents germination of seeds that require light. Be sure all mulching materials are weed free.

3. Cultivation destroys weeds by breaking them apart, cutting them loose from the soil, causing them to dry out, smothering tender tissues, exhausting stored food reserves, or depleting reserves of seeds and vegetative propagules from the soil. Annual tillage effectively controls biennials and simple perennials. Annual and creeping perennial weeds are both able to reestablish. Many annuals can complete their life cycle and produce seed between tillage operations. Perennials generate new plants from vegetative structures, including those that have been cut up by the tillage operation. Care should be taken to avoid damage to ornamental plant roots during cultivation operations.

4. Herbicides can be used for weed control in ornamentals. Due to limited information on selectivity of specific herbicides to the hundreds of landscape species, specific suggested uses are limited. Landscaping usually involves a mixture of species to obtain a desired effect and selectivity of a herbicide to various species may be different. When in doubt about a landscape plants' tolerance to a herbicide the safest practice is to use a

directed or shielded foliage spray with no residual activity. Care should be taken to avoid drift on to nearby desirable plants.

C. PROPER HERBICIDE SELECTION

Weed control results from any given herbicide may vary from year to year or area to area. Understanding the factors that affect herbicide effectiveness aid in selecting the correct herbicide for a particular weed problem.

1. Herbicides may be applied to weed leaves, roots or both for effective control. The effectiveness of soil-applied herbicides depends on the kind of weed present, application rates, uniformity of application, solubility of the herbicide, volatility of the herbicide, rainfall, soil type, and organic matter. Factors influencing foliage applied herbicides include the type of weed present, application rates, uniformity of application, spray additives, stage and rate of weed or crop growth, loss due to rain or light, and retention on leaves.

2. Selective herbicides kill some plants without killing others. Nonselective herbicides kill most plants to which they are applied. Selectivity is often determined by the rate of application, application technique, degree of wetting, soil moisture and texture, temperature, and humidity. The same chemical may be selective or nonselective depending on any of the above influences. Atrazine, as an example, is a soil sterilant at high rates and a selective herbicide in corn at lower rates. 2,4-D is a selective herbicide for broadleaf plants.

3. Preemergent, postemergent, soil fumigant and soil sterilant herbicides are the main types of herbicides used as ornamental plantings. Postemergent herbicides are generally less persistent than preemergent herbicides. Persistent herbicides leave residues in the soil and repeated applications may build up residues that will injure nearby ornamentals. Soil fumigants kill all living organisms in the soil and should be used before planting. Soil sterilants are nonselective and will control most weeds for long periods of time. Care must be taken to avoid contact with surrounding desirable vegetation, including protection of the root zone from soil sterilants.

Granular formulations are the most efficient application technique for preemergent herbicides. Postemergent herbicides are often applied as a directed spray. Soil fumigants are applied as a gas injected into the ground and normally the area must be sealed with a ground covering or moisture. Soil sterilants are generally applied as a liquid spray or granular formulation, depending on weather conditions, soil type, area topography and herbicide used.

4. The following is a list of chemicals currently registered for use in ornamental situations. Please refer to the label for specific use directions and the plant species to which they can be applied.

a. Alachlor (Lasso) is used preemergent, early postemergent, or preplant incorporated. It is used for control of most annual grasses and certain broadleaf weeds in certain ornamental plants and established turf.

b. Atrazine is broadcast or banded in the fall, winter, or early spring to control most annuals weeds and for preemergent weed control in Christmas trees and some ornamentals. Rainfall or sprinkler irrigation provides for leaching the chemical into the topsoil layer where weed seeds germinate. See label for tolerant species.

c. Bensulide (Betasan) is used as a soil-applied preemergent herbicide to control crabgrass, annual bluegrass, and other annual grasses in well-established shrubs, bushes, turfgrass, and dichondra.

d. Cacodylic acid is used postemergence for general weed control. It is quickly degraded in the soil but it leaves a permanent soil residue of arsenic. Care must be taken to avoid desirable foliage.

e. Chloramben (Amiben) will provide up to 8 weeks control of most annual weeds and grasses under established ornamentals; it is useful in parks, cemeteries, herbaria, and other places where annual weed growth is unsightly or interferes with other useful plants.

f. Chlorpropham (Furloe), both liquid and granular, may be used to eliminate annual grasses in nurseries, beneath coniferous plants, and in seedbeds before or at planting time.

g. Danzomet (Mylone) is a soil fumigant used preplant to kill germinating weed seeds, insects, diseases, and nematodes in planting soils. It should be watered into the soil. Allow 2 weeks after treatment before planting or more time if soil temperature is below 60 degrees F.

h. DCPA (Dacthal), WP or granular, is applied preemergence to bare soil in early spring to control annual grasses and broadleaf weeds. It is also an excellent preemergent herbicide to control annual grasses and some broadleaf weeds in turf grasses.

i. Dichlobenil (Casoron) is used preemergence to annual weeds or after cultivation in spring or fall to control a number of annual and shallow-rooted perennial weeds. At heavier dosages dichlobenil will control perennial weeds, including Canada thistle, quackgrass, Russian knapweed, and nutsedge. It can be used around some established ornamentals or on land on which containers of nursery stock are held to keep them weed free.

j. Diphenamid (Enide) is used as a spring or fall preemergent chemical to control weeds in established ornamental trees, woody shrubs, flowers, and other ground cover along highways. Rainfall or overhead irrigation helps incorporate the chemical. It controls a wide variety of annual grasses and broadleaf weeds.

k. EPTC (Eptam) is used pre and postplant in ornamental situations; incorporation is essential. There is no residue problem. It provides effective control of Johnson grass seedlings, nutgrass, quackgrass and many annual grasses. Broadleaf plants are effectively controlled when conditions are favorable for germination.

l. Glyphosate (Roundup) is a foliage applied, non-selective herbicide that is effective on deep rooted perennial weed species and annual and biennial species. It must be applied before emergence of desirable species or directional applications may be made to obtain selectivity.

m. Metham (Vapam) is used preplant as a soil fumigant to control both annual and perennial weeds, including nutsedge and Bermudagrass. No soil cover is needed but the herbicide should be incorporated or watered into the soil.

n. Methyl bromide is a volatile soil fumigant that is used preplant under a gas-tight cover to kill seeds of weeds, nematodes, and soil disease organisms. It is also effective against perennial weeds. It is extremely poisonous and must be handled with care.

o. Napromide (Devrinol) is used for control of most annual grasses and many annual broadleaf weeds. It is a preemergent herbicide. Check label for tolerant species.

p. Naptalam (Alanap) applied as as a direct spray is used as a herbicide to control annual weeds in established woody plants. Avoid getting the herbicide on the ornamentals.

q. Oryzalin (Surflan) is a selective preemergent herbicide for use on non-bearing trees, ornamental trees and shrubs, and flowers. It is effective for controlling many annual grass and broadleaf weeds. Application should be made to allow incorporation by rainfall.

r. Oxadiazon (Ronstar) has preemergence and some early postemergence activity. It controls many annual grass and broadleaf weed species.

s. Paraquat is used to control growing weeds; it is applied by directed spraying or shielding valuable plants. It should not be sprayed under windy conditions, nor allowed to drift. If all vegetation is not killed a repeat treatment may be necessary.

t. Simazine (Princep) is applied preemergence to weeds in fall or spring to control annuals weeds. It can be used only in tolerant species of ornamentals, but may be used on walkways, fence lines, and around buildings and equipment in parks, and in Christmas trees and nurseries.

u. Trifluralin (Treflan), liquid and granular, is used on ornamentals as a preplant soil-incorporated herbicide. Use the chemical when setting out new liners and in established ornamentals for long-range weed control. It can be applied overtop and incorporated on established plants.

Woody Ornamentals	Roundup	Paraquat	Treflan	Dacthal	Eptam	Devrinol	Enide	Ronstar	Lasso	Surflan	Princep	Casoron
Ash		X	X	X			X	X				X
Barberry			X	X	X		X	X			X	X
Birch			X	X			X	X				X
Boxwood	X		X	X	X	X		X		X		X
Cherry			X			X	X					
Cotoneaster			X	X			X	X	X	X	X	X
Cottonwood			X	X		X	X					X
Crabapple	X	X	X	X		X	X	X	X			X
Dogwood			X		X	X	X	X		X	X	X
Elm		X		X							X	X
Euonymus	X		X	X	X	X	X	X	X	X		X
Firethorn (Pyracantha)			X			X	X	X				
Forsythia			X	X			X	X		X		X
Hawthorn				X		X						
Holly	X		X		X	X	X	X	X	X		X
Honeylocust			X	X		X						
Honeysuckle			X	X			X	X			X	X
Juniper			X	X	X	X	X	X	X	X	X	X
Lilac	X		X	X	X		X	X		X		X
Maple	X		X		X	X	X					X
Oak	X	X	X	X	X		X				X	X
Pear						X	X					
Pea shrub											X	X
Pine	X	X	X	X	X	X		X	X	X	X	X
Plum			X			X	X					X
Privet	X		X	X		X	X	X				X
Redbud			X	X			X					
Rose			X	X		X	X	X				X
Rose-of-sharon						X	X					
Russian olive				X			X	X			X	X
Spirea			X	X			X					X
Sycamore			X	X			X					
Viburnum			X	X	X		X	X				
Yew	X		X	X	X	X	X		X			X

*Post-directed Spray

Groundcovers and Flowers

	Roundup[2]	Treflan	Betasan	Devrinol	Enide	Ronstar	Surflan	Princep	Dacthal	Chloramben
Ajuga spp.			X							
Boston ivy									X	
English ivy			X	X	X	X			X	X
Euonymus, Winter-creeper			X			X	X	X		X
Honeysuckle, Japanese		X			X	X		X	X	
Juniper, creeping	X			X	X	X	X	X		
Pachysandra			X						X	
Sedum stonecrop			X				X		X	
Vinca (periwinkle)			X		X	X	X			
Annual flowers[1]	X	X	X	X					X	
Perennial flowers	X		X	X					X	

[1]-Check label for tolerant species
[2]-For directed application only, or use before planting annuals or before perennials begin growth in the spring.

D. CAUSES OF HERBICIDE FAILURE

Considering all of the external forces that can ultimately affect erbicidal action it's amazing they work at all. In most cases herbicide "failure" is actually due to external forces which cause breakdown of the herbicide before it can do the job.

Three major degradation processes (photo, chemical and biological) can occur which can alter the structure of the herbicide molecule and eventually effect its selectivity and activity. Biological decomposition includes the breakdown of the herbicide by soil organisms; chemical decomposition is an altering of the chemical structure of the herbicide in the absence of any living organism; and photo decomposition is the degradation of the molecule by any chemical processes requiring radiant energy from the sun.

In addition, there are several major transfer processes that affect herbicide activity once the herbicide has been introduced into the environment. The herbicide can be absorbed by plants and animals, retained in vegetation and transferred to the harvested products, adsorbed on soil colloids and thus rendered unavailable, volatilized, or lost through surface runoff and leaching. Herbicide runoff and leaching may eventually end up in the water table.

Not only can the above factors alter herbicidal activity, but the chances for human error are present from the initial selection of the herbicide, through its application and crop management.

1. Proper herbicide selection for the target weed is of paramount importance. Some herbicides are very selective, others are noted for their annual grass control, while a third type controls only broadleaf weed species. Still, other herbicides have a relatively broad spectrum in terms of the weed species they will control. Knowing what weed species are present in any particular situation will ultimately help in choosing the proper herbicide for the job. The herbicides listed in Table 1 illustrate the fact that herbicides vary with regard to their ability to control particular weed species.

   In addition to considering the major weed species present in any given landscape situation, the applicator must constantly remember the fact that the weed spectrum will change with repeated application of a single herbicide. For this reason, the development of a program of alternative herbicides which can be used in particular situations should be carefully considered.

Weed Species Responses to Herbicides[1]

COMMON WEED FAMILIES

Herbicides (Common name - Trade name)	Amaranthaceae (Pigweed Family)	Compositae (Daisy Family)	Cruciferae (Mustard Family)	Gramineae (Grass Family)	Leguminosae (Pea Family)	Euphorbiaceae (Spurge Family)
Alachlor (Lasso)	*	0	0	*	0	X
DCPA (Dacthal)	X	0	0	*	0	*
Dichlobenil (Casoron)	*	*	X	X	X	X
Diphenamid (Enide)	*	X	0	*	0	0
EPTC (Eptam)	*	X	0	*	0	*
Simazine (Princep)	X	*	*	0	?	0
Trifluralin (Treflan)	*	0	0	*	0	X

Key: 0=not controlled; X=partially or erratically controled; *=controlled.

[1]Adapted from Agrichemical Age 14(4)

2. Many herbicides effectively control weeds around one plant species while severely damaging another. For example, dichlobenil (Casoron) may be used on junipers to effectively control many perennial weed species. However, this herbicide will cause severe injury if used around Japanese holly. The application of herbicides to various plants is one of the most exacting tasks that an applicator must perform. The aim is always to injure or kill the weeds while at the same time not causing any damage to desirable plants.

3. All herbicides have an optimum time of application. **Preplant** herbicides such as trifluralin (Treflan) are applied prior to the planting of the crop, while **preemergent** herbicides, such as diphenamid, oryzalin and oxadiazon (Enide, Surflan and Ronstar) are applied prior to the emergence of weeds. With nursery crops and in landscape situations we generally think of preemergent herbicides as being used on established crops prior to weed emergence. **Postemergent** herbicides, like paraquat and glyphosate (Roundup), are applied after weeds have emerged from the soil.

Most nurserymen and landscape applicators have seen numerous examples of correct and incorrect timing of herbicide applications. As an example, most nurserymen realize that in order to achieve successful weed control with dichlobenil (Casoron) it must be applied at temperatures below 50 degrees F. Similarly, we might cite chlorpropham as an herbicide which can cause a great deal of damage if applied at the wrong time of the year. This material is labeled for use on dormant plants, and if applied during periods of active growth, can cause severe injury.

Likewise, time of application in terms of weed seed germination can greatly influence the degree of control achieved from an herbicide application. For example, simazine (Princep) applications during the late fall or early winter after the emergence of the cool-season broadleaf weeds will be less effective than if it had been applied in the early fall prior to their germination. Thus, using the proper herbicide at the proper time can help insure good weed control.

4. The amount of herbicide used is of critical importance in ornamental plantings. Herbicides generally have a very narrow range of activity, between acceptable weed control and plant injury. Few herbicides can be used a higher than recommended rates to insure weed control without causing excessive injury to cultivated ornamental plants.

5. Soil type also has a great influence on herbicidal activity. While herbicides are sold nationwide, no two soil types react exactly the same when it comes to herbicide

performance. For example, triazine herbicides (simazine and atrazine) are generally considered to be more effective on soils with a higher content of clay, while materials like trifluralin (Treflan) are more effective on sandy soils.

In addition, weed control with preemergent herbicides can be influenced by the surface condition of the soil at the time of application. Generally the soil should be freshly tilled or disced. Also, if granular preemergent herbicides are being used, the soil surface should be relatively smooth at the time of application in order to achieve a uniform distribution.

6. More than any other soil constituent, the level of soil organic matter determines the activity of herbicides. If in the selection of the herbicide or in the calculation of the rate to apply, soil organic matter is ignored, some erratic results can be expected.

The importance of soil organic matter lies in its capacity to attract and hold a variety of molecules on its surface through the process of adsorption. Adsorption is the sticking of the herbicide to the surface of the organic matter so that it is not free to move in the soil solution and is less available to be absorbed by plants.

Generally, if soils have been amended with large amounts of organic matter, the rate of herbicide application will need to be increased. For example, studies on nursery crops grown in media with varying organic matter levels require higher than recommended rates of trifluralin in order to achieve satisfactory weed control in comparison to similar crops grown in low organic matter medium.

7. Weather conditions during and immediately after application of the herbicide have a great deal to do with the success or failure of a herbicide program. Of all the environmental factors that influence herbicidal activity, temperature and moisture play a major role in determining the success or failure of the program.

a. Preemergent herbicides perform best at soil temperatures that promote rapid, uniform weed seed germination. Cool soil temperatures that delay weed germination can reduce the effectiveness of preemergent herbicides.

Also preemergent herbicides such as EPTC and trifluralin (Eptam and Treflan) volatilize rapidly as soil temperatures increase, and as such, weed control effectiveness is reduced. In the case of Eptam and Treflan, these volatilization losses can be reduced by cultural practices, such as incorporation into the soil immediately following application.

Temperature also influences the performance of postemergent herbicides. In general, these materials work better at warmer air temperatures. The major influence of temperature on postemergent herbicides is on the rate of uptake into the plant. This effort is offset to some extent by the increased rate of drying of the herbicide on the leaf surface at higher temperatures. Once the spray dries, the penetration of the herbicide into the plant is reduced. Generally with the postemergent herbicides, fast movement into the plant is favored by high temperatures, and as a result more favorable weed control can be obtained if the temperature is high at the time of application.

In addition, the thickness and chemical composition of the cuticle of the leaf is influenced by temperature. Cool nights and moderate day temperatures often favor increased cuticle thickness in some weed species, thereby reducing postemergent herbicide penetration into the plant, and ultimately effecting herbicidal activity.

b. Adequate soil moisture prior to the time of herbicide application stimulates uniform and vigorous growth of weeds. Dry soil conditions cause uneven weed seed germination, and often results in poor weed control following herbicide application. Proper timing of preemergent herbicide application in regard to soil moisture levels can help insure good weed control.

In addition, rainfall or irrigation is essential for successful preemergent weed control. Water is necessary to carry the herbicide into the top 1/2 inch of the soil where the maximum number of weed seeds will germinate. A delay in rainfall of more than a few days following application may severely reduce the degree of weed control achieved. Of course, with irrigation this is not a problem.

For many preemergent herbicides, a period of 10-14 days without moisture to incorporate them into the soil following application, is often the cause for complete failure. During this period without rainfall, the herbicide may actually be destroyed by exposure to sunlight while it lies on the soil surface, or weeds may germinate and emerge without taking up the herbicide.

In contrast, a heavy rainfall of several inches soon after preemergent applications can be detrimental to herbicidal activity. It may carry the herbicide beyond the major weed seed zone or may actually remove the herbicide from the site of application due to runoff.

Observation and good record keeping is a key to a successful weed control program. The nurseryman or landscape applicator should not be looking for 100% control with his weed control program since this could ultimately result in soil sterilization, but rather for control in the 90-95% range. Thus, by carefully observing when weeds are beginning to reinfest a treated area, the applicator can carefully plan and time his reapplications in order to insure success. Integration of other weed control tools, such as cultivation and mulching, will add to a total weed management program.

CHAPTER IV

DISEASE AGENTS OF ORNAMENTALS

A. INTRODUCTION

Three factors or variables must be present before a plant disease can occur. These three variables are: a host plant that is susceptible to disease, a pathogen (a microorganism attacking the plant), and an environment that favors the interaction of the host and pathogen. Pathogens (fungi, bacteria, nematodes, etc.) may be present around the host plants, but they will not infect and cause disease unless the environment is favorable for the interaction to take place.

A specialized environment is often necessary to "condition" the plant, causing it to become susceptible to the agent. Infectious disease agents generally require a rather narrow range of favorable environments to infect the plant. Environment not only determines whether disease develops but also at what rate and with what degree of severity.

Consider the following examples:

A sudden drop in temperature in the fall or early winter increases the susceptibility of plants to fungi which causes cankers. Sudden freezing temperatures may damage or kill tissue permitting entrance by disease causing agents.

Waterlogging of the soil contributes to the development of certain root rots.

Long periods of rain can cause an increase of such diseases as scab, leaf spots and fire blight.

B. TYPES OF PLANT PATHOGENS

Fungi, bacteria, viruses, nematodes, mycoplasmas and parasitic plants all cause diseases of ornamentals. These organisms, and some of the more common diseases of ornamentals which they cause, are describe below.

1. Bacteria

Bacteria comprise a diverse group of single-celled microbes, which cause many diseases of ornamental crops. Commonly encountered diseases include bacterial leaf spot of English ivy; fireblight on crabapples, mountain ash, hawthorn, cotoneaster, and Pyracantha; and crown gall on crabapples and euonymus.

Bacterial fire blight affects a number of ornamental plants and displays the following symptoms:

Blossoms and leaves suddenly wilt, turn dark brown, shrivel, and die, but usually remain attached. Droplets of a tan colored bacterial exudate may frequently be present.

Secondary infections start in the small twigs, progress down the stem, and may involve whole branches.

Blighted terminals may bend to look like a shepherd's crook.

Dark streaking of the wood extends several inches beyond the diseased area.

Cankers on the limbs are shrunken and separated from healthy wood. They are dark brown to purple and a tan to orange bacterial exudate often oozes from them.

The bacteria overwinter in cankers on the plant. They are spread by wind-blown rain, insects, and pruning tools.

2. Nematodes

Several types of very tiny roundworms or eelworms cause plant diseases on ornamentals. Lesion nematodes (Pratylenchus) and pin nematodes (Paratylenchus) cause plant stunting and poor growth because their feeding weakens the root system. The root knot nematode (Meloidogyne) causes nodules to form on roots, thus impairing root function, and resulting in stunting of the plant.

3. Viruses

Viruses are systemic plant disease-causing agents that live and multiply only within living cells of the host. They are most often spread by plant contact, sucking insects, especially aphids and sometimes leafhoppers, and in vegetative plant material. Symptoms are diverse, depending on the virus. Generally, vein banding, mosiac (a mixture of irregularly shaped dark and light green areas on the leaf), flecking, or spotting will show up on leaves. Sometimes, growth abnormalities will appear. This may be similar to damage caused by herbicides. Viruses also can cause stunting of plants.

4. Fungi

Fungi are simple microorganisms containing no chlorophyll. They do not manufacture their own food and obtain it from either living plants or animals or from decaying organic matter. The fungi cause a number of different types of disorders of ornamental plants.

a. Powdery mildews: The powdery mildew-causing fungi are host specific. Common hosts are rose, zinnia, crabapple, and lilac. Generally, each plant is unique

in that the powdery mildew which infects it will not infect any other plant. The white growth appearing on leaves and stems is the fungus growing on the surface of the tissue. Small structures, called haustoria, grow within the host cells, injuring them as they obtain food. The powdery mildew fungus will not usually kill a plant, but may weaken it and reduce its ability to survive the winter. Unsightly fungus lesions greatly reduce the quality of the plant. Mildews that develop late in the summer cause little harm since the plant is nearing death or dormancy.

b. Rusts: Like powdery mildews, rusts are also host specific. Rusts usually sporulate abundantly on leaf tissue. These masses of orange to dark red-colored spores are what we notice on plants when they become diseased. Rusts are seen on many ornamentals including poplar, cottonwood, rose, ash and hollyhock.

Rusts are, for the most part, cool weather diseases. Rust spores are spread by currents and in splashing water. They must have water in order to germinate and infect the leaf.

c. Leaf spotting and blighting fungi: Like rusts or mildews these fungi are spread either long distances by air or shorter distances by splashing water. Among this group are Entomosporium leaf spot on hawthorns, scab on crabapples and Pyracantha, black spot of rose, Herpobasidium blight of honeysuckle plus many others. Many leaf spotting fungi require water on leaf surfaces for infection to occur and splashing water for spread of spores from leaf to leaf.

d. Plant wilting fungi: Verticillium is a fungus that causes wilting of a large number of woody ornamentals including maple and Russian olive. The fungus invades injured roots, grows into the stem, and plugs the vascular system of the plant. Along with wilting, it often causes discoloration of the vascular system. It also has a resting structure to help it persist over time. Generally, plant debris left after harvest will contain these structures. Saturated soil and other conditions that favor poor root growth often result in increased Verticillium wilt.

Another wilt organism is Ceratocytis ulmi, the causal agent of Dutch Elm disease. Spores of this organism are carried on the body of elm bark beetle to the branches of the elm. As the beetles feed, the spores are deposited and germinate in the feeding wounds.

In both diseases, leaf wilting and yellowing leading to leaf necrosis begin in one branch and progress through

the tree. Dead and dying branches, sparseness of the crown, and reduced growth are common symptoms.

e. Water molds: Pythium and Phytophthora are often called water molds because they have a spore stage that is adapted to spread by swimming in water. These organisms attack a wide variety of plants, causing root rots, stem rots, and cutting rots. Many times, they will not kill a plant. They will "prune" the root system, resulting in poor growth, yellowing, or stunting of the top portion of the plant. Poorly drained or heavy soils lead to disease problems caused by water molds.

f. Cutting rots and damping off organisms: The organisms responsible for cutting rots and damping off have already been mentioned. Cutting rots are often caused by water molds, bacteria, Rhizoctonia, and Botrytis. Damping off often results from invasion of water molds or Rhizoctonia.

g. Root and crown rotting fungi: Aside from water molds, many other fungi cause root and crown rots. The fungus Rhizoctonia lives in the soil and attacks a wide variety of plants. Some species of Fusarim, Cylindrocladium, Sclerotinia, and Thielaviopsis behave similarly. All of these fungi can persist in the soil for many months through specially adapted resting structures.

h. Stem and twig cankering fungi: Many fungal organisms, such as Cytospora, Phomopsis, Diplodia, and Fuscicoccum, cause stem or twig cankers. Notable examples include twig blight on juniper, Cytospora canker of poplar, and tip blight on Red or Austrian Pine. These pathogens primarily sporulate in the spring. The spores are spread by splashing water and wind.

C. DISEASE CONTROL FOR ORNAMENTALS

The principal of fungicide application differs from that of application of insecticides and herbicides. Most fungicides are not systemic in their action. Only that portion of the plant which is coated with fungicide is protected from disease. Therefore, uniform coverage is essential.

1. Protective Fungicides

These are applied to foliage, flowers, and fruit, depositing a protective film of chemical to resist the establishment of disease. They are subject to weathering and must be reapplied regularly during an infection period of a disease, both to replace weathered material and to protect new

foliage. They are applied before disease inoculation to prevent infection.

2. Eradicant Fungicides

These are applied to foliage, flowers, and fruit, controlling the fungus disease after initial infection. They destroy an established disease. Misuse may cause phytotoxic plant symptoms.

3. Systemic Fungicides

These can be applied less frequently and are not accessible to weathering, but can be diluted by plant sap. They enter the plant and move internally acting as protective or eradicant chemicals.

4. Soil Fumigants

Use of these chemicals will control soil-borne fungi, bacteria, nematodes, insects and weeds seeds. They are economically feasible in production and establishment of high value ornamentals.

There are no known chemicals for the control of viruses, and chemicals are only marginally effective in control of bacterial disorders. Cultural and sanitation practices are extremely important disease control tools in addition to the use of fungicides.

D. FUNGICIDES FOR ORNAMENTAL PLANTS

There are more than 150 different chemicals used to control plant diseases. This list contains some that are currently registered for use. The list does not constitute a recommendation of all fungicides mentioned. Consult the label for specific use directions.

1. Foliage Fungicides

Common Name	Some Trade Names	Comments
benomyl	Benlate Tersan 1991	*Botrytis* and *Sclerotinia* diseases, *Septoria* leaf spots. Smuts, *Rhizoctonia* diseases. Powdery mildew protectant. Absorbed by foliage. Taken up by roots with systemic action.
captan	Captan Orthocide	Fungus leaf spots. Does not control rust diseases.

chlorothalonil	Bravo Daconil 2787	Botrytis diseases, Alternaria leaf spots. Tablets are heated to generate dust for greenhouse space treatment.
cycloheximide	Acti-dione PM Acti-spray	Powdery mildew and rusts of roses and other plants. Eradicant action.
DCNA or dicloran	Botran	Botrytis and Sclerotinia diseases. Soil treatment for Stromatinia neck rot of gladiolus.
dinocap	Karathane	Specific for powdery mildews. Eradication action, little residual action. Apply with caution above 85 degrees F. Use 6 oz. (22.5%) or less on greenhouse roses.
ferbam	Carbamate Fermate Karbam Black	Fungus leaf spots, rusts.
fixed copper	Copper 53 COCS Kocide Oxycop	General purpose fungicide and bactericide. Overall growth of some plants may be reduced.
folpet	Phaltan	Similar to captan. Powdery mildew of begonia.
mancozeb	Dithane M-45 Fore Manzate 200	Fungus leaf spots, Botrytis, rusts.
maneb	Dithane M-22 Manzate	Fungus leaf spots, Botrytis, rusts.
oxycarboxin	Plantvax	Rust diseases. Systemic.
piperalin	Pipron	Powdery mildew fungicide. Primarily eradicant action.
streptomycin	Agri-mycin Agri-strep	Bacterial leaf spots and cutting soak (dieffenbachia). May cause severe chlorosis of some plants (pelargonium).

sulfur	(Various)	Powdery mildew protection; no eradication action. Apply with caution above 85 degrees F.
thiabendazole	Mertect	Controls Fusarium and Penicillium bulb and corm rots.
thiophanate-methyl	Topsin-M Fungo 50	Botrytis and Sclerotinia diseases. Powdery mildews. Systemic.
thiram	Arasan Pancram TMTD Thylate	Seed treatment. Fungus leaf spots, Botrytis diseases.
zineb	Dithane Z-78	Fungus leaf spots, rusts, Botrytis diseases.
ziram	Niacide Z ZC Spray Zerlate	Fungus leaf spots, Botrytis diseases.

2. Soil Fungicides

Common Name	Some Trade Names	Comments
captan	Captan Orthocide	Controls water molds and some other fungi but not Rhizoctonia. Can be combined with PCNB.
diazoben	Dexon	Specific for water molds. Used at 30 to 100 ppm at 10- to 30-day intervals. Use at once; light-sensitive.
ethazol	Truban Koban Terrazole	For water molds. Best if incorporated in soil before planting.
nabam	Dithane D-14 Dithane A-40 Parzate Liquid	Spot treatments to prevent disease spread. Little residual action.
PCNB	Brassicol Terraclor Fungiclor	Specific for Rhizoctonia, Sclerotinia species, and Sclerotium species. Not effective against water molds. Good residual action.

3. Soil Fumigants

Common Name	Some Trade Names	Comments
methyl bromide	Bed Fume Bromex Brom-o-gas Brozone Dowfume MC-2 Edco MBX Pano-brome Pano-fume Tri-brome Weedfume	Must be tarped. At high dosages, effective against fungi. Excellent weed and nematode control. Bromine residues may be toxic to some plants (carnation, snapdragon). No not breathe the fumes of this chemical. Restricted material.
chloropicrin	Chloro-pic Larvacide Picfume Tri-clor	Used for control of Verticillium wilt. Fumes are toxic to living plants. Not recommended for flats. Best if combined with methyl bromide. Restricted material.
methyl bromide + chloropicrin combinations	Larvabrome Mumfume Pathofume Terr-o-gas Tri-con Trifume	Combines the qualities of both ingredients. Must be tarped. 55% chloropicrin - 45% methyl bromide at 23 gal./A. controls Verticillium. Restricted materials.
SMDC or metham-sodium	Vapam VPM	Good weed control. Fumes are toxic to living plants.
DMTT or dazomet	Mico-fume Mylone	Same as SMDC. Material is a powder.
MIT	Vorlex (20% MIT, 80% chlorinated hydrocarbons)	MIT is the volatile toxicant formed by SMDC and DMTT. Good nematode control.
formalin	Formaldehyde	Soil must not dry out during aeration period. Tarp-covered for first 24 hours of treatment time. Fumes toxic to living plants.

CHAPTER V

TURF INSECT PESTS

A. SOIL INHABITING INSECTS

1. White Grubs (Coleoptera: Scarabeidae)

Description

The term "grub" is used to describe the larvae or immature stage of many species of beetles. Beetles have four life stages, the egg, larva (grub), pupa, and adult. Grubs generally range in size from 1/2 to 3/4 in. (13-18 mm) and are white to grayish, with brown heads and six distinct legs. They generally assume a C shaped position in the soil, see the appendix. The grubs feed on the roots of grasses, shrubs, and trees. The adult beetles are generally fairly large insects, with front wings developed into a hard shell. They vary in color from tan to brown or black and a few are brightly colored, green, reds or striped like the ten-lined June beetle. The beetles are attracted to light and are often seen around yard or porch lights.

Biology

A grub's life cycle varies in length from one up to five or seven years. In lawns the life cycle is probably from one to three years depending on the species. Grubs overwinter in the soil. In March the grub comes out of hibernation and moves to the upper soil layer to feed. They are normally found feeding in late March through April. In May the grubs pupate. The pupa is a resting stage in which larval or grub muscles, tissues and organs are broken down and the adult muscles, tissues and organs formed. During mid-May through June the adults emerge. Mating takes place in June and by July a new batch of eggs are laid, the larva or grub hatches, thus beginning a new life cycle. By October or November the grubs move downward in the soil to hibernate or diapause for winter.

Damage Diagnosis

Evidence of grub damage include patches of wilted, dead, or dying turf visible during spring and fall. In the spring, large flocks of birds feeding on the lawn may be a sign of grub infestation. Turf damage by skunks or other small mammals feeding on grubs is also an indication of infestations. Seriously damaged turf can be rolled back like a carpet.

Sampling

Grubs can be sampled in April and May by cutting out a square foot of sod, figure 2. Cut only three sides of the soa, use the uncut side as a hinge, lay the sod back and look for the C-shaped grubs. Soil around the roots should also be inspected for grubs. A trowel can be used to dislodge the soil around the roots. Count the grubs, replace the flap, tamp it down, and even put on a little water to insure continued growth of the sampled area. Don:t rely on one sample to diagnosis problems. Two or three other sites should be sampled. Total up the number of grubs and divide by the number of samples. (15 grubs ÷ 3 sites = grubs/site). If the average number of grubs is three or more, control should be considered.

Control

Controls should be initiated in the spring after the grubs have moved toward the soil surface to feed or in the summer after the eggs have hatched and the grubs are feeding. The egg and pupal stage of the grub is not susceptible to chemical control, insecticides applied during these stages are ineffective.

2. Billbugs Spenophorus sp. (Coleoptera: Curculionidae)

Description

Several species of billbugs can seriously damage turf in the U.S. depending on the grass species. The bluegrass billbug is a problem in lawns planted to Kentucky bluegrass.

Billbug larvae are legless, white soil inhabitants, 3/8 in. (9 mm) long and have a yellow to brown head. The tail end of the larvae is somewhat larger than the head end.

The adult billbug is 1/5 to 1/4 in. (5-6 mm) long. They have long snouts with strong jaws or mandibles at the end of the snout. Their color is clay yellow, to reddish brown to pitch black.

Biology

The bluegrass billbug passes the winter as an adult in the lawn and nearby sheltered areas. In spring they move about and are commonly observed wondering on driveways and sidewalks. During May and June the adults mate and lay eggs in holes they chew in grass stems. The eggs hatch in approximately two weeks. The larvae feed within the grass stem for a time and then burrow down the stem to feed on the crown. Later they move to the root zone, feeding on roots and rhizomes. Larvae are usually found from mid-July to mid-August. After completing development, they pupate in

the soil in small pupal cells and emerge as new adults. The new adults are abundant during late September and October.

Diagnosis

The observation of adults wandering on driveways and sidewalks during May and June or late October and September is a good indicator of potential problems. Small patches of turf appear to be dying from June to September. Turf damaged by billbug larvae is easily pulled out by hand with the stems breaking off at the crown.

Sampling

A good indication of billbug larval activity is a fine, white sawdust-like material mixed with soil left by the larvae feeding in the root zone. Use a knife to probe among the roots to look for larvae.

Control

Controls should be initiated against the young larvae before they move into roots and the crown of the plant. Chemicals cannot reach them once they reach these locations.

B. THATCH INHABITING INSECTS

1. Sod Webworm Crambus spp. (Lepidoptera: Pyralidae)

Description

Sod webworms are made up of a complex of species in the pyralid moth family. They include the tropical sod webworm, vagabound crambus, bluegrass sod webworm etc. The webworm adult or moth is small, grayish-white to beige with a wing spread of 3/4 in. (18 mm). When at rest, the wings are folded close to the body rather than spread out like most moths. The head has a snout-like projection in front, see the appendix. The larvae are caterpillars which have three pair of legs on the thorax and five pair of prolegs on the abdomen. They vary in color from greenish to beige, brown or gray depending on the species. When mature they are 3/4 in. (18 mm) long and usually have dark circular spots scattered over the length of the body, see the appendix.

Biology

Sod webworms overwinter in the soil. The larvae or caterpillars become active in April or early May. First generation adults emerge in May. The adults hide in lawns and shrubery during the day. At night they fly over the lawn scattering their eggs. The eggs hatch in about one week to ten days. The larva feed near the ground on grass blades at night. They hide in the soil and thatch during

the day. The moths are readily attracted to lights. As the caterpillars or larvae mature, they construct tunnels or burrows through the thatch which are lined with a silk-like web. The burrow may extend into the soil. The caterpillar pupate in the webbed tunnels and emerge as moths to begin a new life cycle. The life cycle is completed in six weeks. There are probably two generations per year in Montana.

Diagnosis

Flocks of birds frequently return to the lawn to feed. These birds leave many small circular holes, probe holes, in the turf often with tufts or pulled up turf. From mid-May to October the grass turns brown in patches, the size of a saucer, in the hottest and driest areas of the lawn. These areas may expand to form large irregular damage which may also be caused by lawn diseases or white grubs. Inspect grass thoroughly near the soil surface for feeding. Grass will be chewed just above the soil. Fresh clippings are usually present. Look for green grass or fecal pellets. Examine thatch and the soil to a depth of one inch for larvae, silken tubes or webbing.

Sampling

Sod webworm can be brought to the surface by application of a tablespoon of 1% to 2% pyrethrins in one gallon of water on one square yard of lawn. Pyrethrin irritates webworms causing them to squirm to the surface in 5 to 10 minutes. If 15 or more larvae are found per square yard, control may be desirable. It is important to sample in more than one area before deciding to control sod web worms. A fairly effective substitute for pyrethrins is 1/4 cup of household detergent.

Control

The following steps may help insure satisfactory results:

a. Be certain sod webworms are the primary problem, it is important to sample for the webworm,

b. Mow the lawn before application and remove clippings. The insecticide is less apt to get hung up on long blades of grass.

c. Water thoroughly in the afternoon.

d. Apply an insecticide in the late afternoon or early evening. The insecticide will be fresh and available when the webworms begin to feed in the evenings.

e. Water lightly to wash the insecticide off grass blades and into the turf.

To time control, keep a mental note of how many moths you kick up each week while mowing. There will be a peak in moth activity, then activity will drop off. Two to three weeks after the drop off is the time to treat. Populations should exceed 15 larvae per square yard to make treatment economical.

Control of sod webworms in other states is recommended around June tenth for the first generation and August tenth for the second.

2. Chinchbugs Blissus leucopterus leucopterus (Say) (Homoptera: Lygaeidae)

The hairy chinchbug is a pest of northern turf grasses causing damage to bluegrasses, fine fescues, bentgrass and probably zoysia grass.

Adult chinchbugs are 1/5 in. (5 mm) long, black with white wings folded over the back. They are true bugs and thus have sucking mouthparts. The wings of some extend to the tip of the abdomen while others may extend halfway to the tip.

The nymphs (immatures) have the same general body shape as the adults. They range in size from 1/20 in. (1 mm) long, soon after hatching, to nearly the size of an adult. After hatching the nymphs are bright red with a distinct white band on the abdomen. This color changes first to orange, then orange brown, then black as the nymph matures through five nymphal growth stages or instars.

Biology

In northern states such as Montana, the adults diapause (this is a resting state used by insects to avoid periods of inclement weather or food shortage) during the winter. They resume activity in late March and April. Egg laying begins in May. The nymphs hatch from the eggs in early to mid-June. Lawn damage from the first generation chinchbug feeding will be most evident in July and August. A second generation appears in late August to September. The chinchbug prefers sun and heat and is generally not a pest where the lawn is shaded. While feeding, the chinchbug injects a toxic, enzyme which causes the blade to turn brown and die.

Diagnosis

Often damage by the first generation will be overlooked because the grass is growing so well.

The grass turns yellowish brown, dries out, and dies in sunny areas and along sidewalks and driveways. Chinchbug damage is often mistaken for grass going dormant.

Adults may be seen wondering across sidewalks and driveways on warm afternoons. Close examination of the grass, particularly the thatch, usually exposes the insects. Heavy infestations are capable of killing a lawn rapidly. They may move across a lawn in several days.

Sampling

Remove both ends of an empty coffee can, cut the rim of one end to produce a sharp edge and push the can two to three inches into the turf in an area with a suspected chinch bug infestation. Fill the cut can with water, and wait five to ten minutes. If chinchbugs are present they will float to the surface.

Controls

The chinchbugs are susceptible to infection by a fungus, Beauveria sp. The infections by the fungus can be promoted by providing adequate moisture for good lawn growth. The second generation can be reduced drastically by the fungus under good moist growing conditions.

If chemical controls are warranted, water the lawn before spraying. Apply 1/2 to 1 inch of water to bring the insects to the surface.

C. OCCASIONAL INSECT PESTS

1. Leafhoppers (Homoptera: Cicadellidae)

Description

The leafhoppers that attack grass are small triangular or wedge shaped insects, 1/8 to 1/5 in. (3-5 mm) long, ranging in color from green to yellow to brownish gray. At rest they hold their wings tent-like or roof like over their body. Leafhoppers have piercing, sucking mouthparts, like chinchbugs. The adults are active and fly quickly when disturbed.

Biology

The adult female lays eggs in or on the plant tissues. The nymphs, or immature, leafhoppers that emerge from eggs resemble the adults in shape but are smaller, paler and wingless. In Montana there is probably only one generation per year, Southern states may have as many as three generations per year.

Damage Diagnosis

Look for white to brown spots on individual blades of grass. Under heavy infestations the grass may appear bleached, dried and have a stunted, thinned appearance. Damage similar to that caused by the chinchbug is less likely to be restricted to sunny areas. Leafhoppers inject their saliva into the conductive tissue of plants. The saliva contains enzymes which help liquify plant tissue so that they can be sucked easily through the beak of the leafhopper. The saliva also contains toxins which kill the surrounding plant tissue, this leads to the white or brown spots on the leaves. The leafhoppers are unable to utilize all the food they consume, much will be excreted as honey dew on the grass. Honey dew is mainly composed of undigested plant sap and water.

Sampling

Adult leafhoppers can best be sampled using a sweep net. Use visual inspection to sample for the nymphs.

Control

Control criteria is not established for leafhoppers; they are usually a minor problem.

2. Cutworms (Lepidoptera: Noctuidae)

Description

The adult cutworm, or night-flying moth, has drab brown or gray front wings and dirty white or buff colored hind wings. They have a 1 1/2 in. (38 mm) wing span. The moths are approximately three times larger than the sod webworm moths. The larvae, or caterpillar, are worm-like in shape with three pair of true legs on the thorax and five pair of pseudo legs, or prolegs, on the abdomen. The full grown larvae may be 1 1/2 to 2 in. (35-50 mm) in length, gray, brown or black in color with spots or stripes.

Biology

Adult moths lay their eggs at night on the grass surface. The eggs hatch in approximately two weeks and the larvae feed at night for about four to five weeks, depending upon the cutworm species. The day is spent below the surface of the ground or under clods and plant debris. There may be from one to three generations of cutworms per year depending on the species. Cutworms may overwinter in the larval, pupal, or egg stage.

Damage Diagnosis

Grass blades are chewed unevenly along the edges. In newly seeded lawns, spring grass plants may be chewed or cut off near the ground surface. Birds feeding on the lawn and the presence of bird probe holes may be a good indicator of a cutworm infestation. Examination of the feeding area may reveal green excrement pellets, frass, which is three times longer than that of the sod webworm.

Sampling

See sod webworm for notes on sampling and control.

D. LIST OF MINOR PESTS, OR THOSE RARELY ENCOUNTERED IN MONTANA

aphids or greenbugs
armyworms
Hyperodes weevils
Vegetable weevil
scale insects
winter grain mite
clover mite
frit fly
ground pearls
wireworms
crane fly larvae
underground scales

Some Beneficial insects

big-eyed bugs - feed on chinchbug nymphs
ladybird beetles - aphids
ground beetles - caterpillars (cutworm, armyworms, sod webworm)

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CHAPTER VI

WEEDS IN TURFGRASS

Turf grass management, including homes, parks, public gardens, cemeteries and golf courses, is a multimillion dollar business. The best defense against weeds is development of a dense, vigorously growing turfgrass. Establishment of strong turfgrass involves selection of the best variety of adapted grass species, good soil, correct soil acidity, proper fertilization, proper watering, and control of all pests - weeds, insects, and diseases. Weeds will invade turfgrass if the turf is mechanically disturbed, if it is worn by excessive use, or if diseases, insects or drought partially reduce the stand. In addition, some weeds are strong competitors and can invade easily if found in the area.

Use of all available control methods in an integrated management approach is the most effective way to combat turfgrass weeds. Cultural practices, mechanical methods and herbicides all play an important part in turfgrass weed management. Please refer to Chapter III for specific information on weed life cycles.

A. WEED CONTROL METHODS

1. Cultural practices include fertilization, liming, watering and mowing. These practices are utilized to help eliminate factors that favor weed invasion.

   a. A good fertilization program furnishes lawn grasses with necessary plant nutrients throughout the growing season and tends to discourage weed invasion through competition furnished by a vigorous turf. Nitrogen, phosphorous, and potassium are common nutrient needs and should be in good supply when turf species are making the most rapid growth. Cool season grasses of the northern temperate climate should be fertilized more heavily in the fall, with a lighter application in the spring. Some fertilization may be needed in the summer but nitrogen levels should be declining before expected periods of hot or dry weather.

   b. A pH range of 6.0 to 7.0 is considered best for turfgrass growth because it provides favorable nutrient availability and microbial activity. Ground agricultural limestone can be used on acidic and clay soils. Late fall or winter applications are best.

   c. Proper watering also aides in establishment of a vigorous turf. Sandy soils require frequent watering, while clay soils require less frequent watering but larger amounts of water. Water at the first sign of wilt and apply enough to wet the soil to a depth of at

least 5 inches. Avoid watering lightly at frequent intervals; this is wasteful and causes shallow growth of grass roots. It also stimulates germination and growth of weeds. Light, frequent irrigation encourages the invasion of annual bluegrass and crabgrass.

d. Weekly mowing to a height of 2 to 3 inches shades the soil and protects grass roots from the damaging effects of summer heat. Close mowing, especially during hot weather, weakens cool-season turfgrass and invites weed invasion. High mowing is an excellent deterrent to the germination and growth of many annual weeds.

2. Mechanical control methods include digging, pulling, aerating and dethatching.

a. Digging and pulling are simple, effective ways of controlling a few scattered plants. Dandelions should be cut 2 to 4 inches below the crown to prevent regrowth. Pulling works best following a heavy rain or after deep watering. Small patches of undesirable grasses can be cut out with a sharp spade and a replacement piece of sod set in from an inconspicuous place in the lawn. Be sure replacement sod is firmed into place and well watered until it becomes established.

b. Aerating and dethatching enhance growing conditions. These operations must be timed during a period of rapid regeneration of the turf. They should also not uncover soil during a time of annual weed seed germination. Some preemergent herbicides do not work effectively if the area is dethatched or aerated soon after application. Application soon after these operations may suppress grass regrowth.

3. Herbicides should only be used when necessary and as part of a complete lawn management program. For general turfgrass maintenance, selective herbicides must be used. An excess rate of almost any herbicide will damage lawn grasses and many commonly used turfgrass herbicides may kill one weed and not affect others. Nonselective, nonresidual herbicides may be used for preplant treatment or lawn renovation.

B. PROPER HERBICIDE SELECTION

Proper herbicide selection is dependent on the type of weed to be controlled (annual or perennial, grass or broadleaf) and the purpose of the weed control (establishment of a lawn, renovation, maintenance). Three types of weed control treatments include preplant, preemergence and postemergence.

1. Preplant weed control is one of the most effective ways of dealing with weeds in new seedings, it eliminates weeds before the turf is established. Preplant herbicides are generally practical only on sites of high economic value. Special site preparation and herbicide application and the need for higher herbicide rates makes this an expensive control.

Proper seed bed preparation is essential for effective weed control. This includes correct timing of planting, tillage to 3-4 inches, soil amendment and fertilizer application and soil fumigation. Cool season grasses are most successful if seeded during the late summer. This lessens competition from most annual weed species. A few herbicides may be used on new grass seedlings to prevent weed competition.

Preplant herbicide treatments are most often used on golf course establishments, for home lawns requiring fine turf, and for commercial sod production. Soil fumigants such as methyl bromide, metam, and dazomet may be used to sterilize the soil. Cacodylic acid may be used to destroy vegetation upon contact and is used for total vegetation control. Several applications are necessary for control of persistent perennials such as smooth brome and tall fescue.

2. Preemergent herbicides are applied to the soil to stop weed seed germination or growth. They are most effective on annuals and some perennials which start from seed. Most preemergence products have little effect on emerged seedlings.

Proper lawn preparation is essential for optimum performance of these herbicides. All trash, leaves and excess dead grass must be removed from the lawn. Application must be in strict accordance with label directions and it must be distributed evenly. Double coverage at half the rate in two directions ensures more even distribution. After application of the herbicide the lawn should be watered. This moves the chemical into the soil and into contact with the germinating weed seedlings.

Currently registered preemergent turfgrass herbicides include:

a. Benefin (Balan) controls annual grasses in most perennial turf grass but should not be used on bentgrass. Use only on well established turf. Do not reseed until six to eight weeks after application.

b. Bensulide (Betasan) is an organic phosphate herbicide. It controls annual grasses in established cool season turf. Reseeding should not be attempted for 4 months after application.

c. DCPA (Dacthal) is especially effective on germinating grasses and also the seed of certain broadleaf species including chickweed and purslane. Dacthal is used extensively for weed control in ornamentals, small fruits, and in some farm crops. Do not use on new grass until after the first mowing. Reseeding to grass should be delayed for 10 to 12 weeks after using.

d. Siduron (Tupersan) is a substituted urea compound. It effectively controls most annual warm season weedy grasses and has the unique quality of not interfering with the germination of newly seeded cool season perennial grasses which include bluegrass.

3. Postemergent herbicides control weed species once they have begun to grow. They are generally selective for broadleaf weeds and may be used in combination or in rotation with other herbicides to control a broader spectrum of weeds. Postemergent herbicides should be applied when weeds are rapidly growing and before seeds mature. Care must be taken to avoid drift to nearby susceptible ornamentals. The rate of treatment and precautions on the label should be closely followed.

The most common postemergent herbicides include:

a. Amitrole (3 amino-1,2,4-triazole) inhibits chlorophyll formation in plants. It is used for spot treatment to destroy undesirable plants and for total vegetation control.

b. Arsonates are known collectively as organic arsenicals. The principal products are DSMA (disodium methanearsonate), MSMA (monosodium acid methanearsonate) and MAMA (monoammonium methanearsonate). The arsonates are used to control annual grassy weeds such as crabgrass and foxtail found in perennial grasses. They generally kill by foliage contact but also move within some plants to a limited extent. Arsonates are used for nutsedge control. Don't confuse these much safer organic arsenicals with the more toxic inorganic arsenicals such as sodium arsenite, lead arsenate, and calcium arsenate.

c. Bentazon (Bazagran) is the most effective material available for yellow nutsedge control in turf. However, it is ineffective on purple nutsedge. Basagran has an excellent margin of safety for turf grasses. Apply 3/4 to 1-1/2 oz. of 4 lb per gallon Basagran per 1,000 sq. ft. when the plants are growing vigorously. This is usually in June, July, and August. Repeat treatments may be necessary. Withhold mowing for 4 to 5 days before and after application.

d. 2,4-D (2-4-dichlorophenoxyacetic acid) is a growth regulating hormone compound. It is formulated principally as salts and esters and is sold under a wide variety of trade names. It is available as liquids, tablets, powders, wax bars and granules. The use of ester formulations should be avoided because of the hazards of fume damage to other plants in the vicinity.

e. Dalapon (Dowpon and Bastapon) shows greatest activity on grasses. Dalapon must be used as a "spot treatment" on clumps or patches of undesirable grass since it is not selective and kills all grasses.

f. Dicamba (Banvel) is used in mixtures with other herbicides such as 2,4-D and MCPP. Its activity in plants is similar to the action of 2,4-D. Severe injury can occur to desirable trees, shrubs, and other ornamentals through root uptake particularly from granular formations. Banvel is especially effective on clovers, chickweeds and red sorrel.

g. Glyphosate (Roundup) is a nonselective translocated herbicide. It kills annual and perennial grasses and broadleaf plants. One of its principal uses is lawn rennovation where individuals wish to kill all existing vegetation and reseed. The Roundup label specifies that the product should be used by commercial applicators. Application rates are 2 to 3 oz. of Roundup per 1,000 sq. ft. Delay mowing and tillage 5 to 7 days before and after application.

h. MCPA (2-methyl-4-chlorophenoxyacetic acid) and MCPP or mecoprop (2-methyl-4-chlorophenoxypropionic acid) are herbicides similar to 2,4-D. At higher rates, they are less likely to cause noticeable adverse effects on grasses than similar rates of 2,4-D.

C. WEED RESPONSE TO HERBICIDES

Weed	Pre-emergence[a] Control	Post-emergence control[b] 1st Choice	2nd Choice
Barnyardgrass	Yes	Arsonates	
Bellflower, creeping	No	Banvel	
Bindweed, field	No	2,4-D	Banvel
Bluegrass, annual	Yes		
	Betasan, Dacthal		
Brome, smooth	No	Banvel[c]	Dalapon[d]
Chickweed, common	Some	Banvel	Arsonates
Chickweed, mouseear	Some	Banvel	Arsonates
Clover, white	No	Banvel	
Dandelion	Seedlings	2,4-D	
Dock	No	Banvel	2,4-D
Fescue, tall	No	Dalapon[d]	
Foxtail	Yes	Arsonates	
Ivy, ground	No	Banvel	2,4-D
Knotweed, prostrate	Yes	Banvel	2,4-D (early)
Kochia	No	2,4-D	
Mallow	No	2,4-D (Fair)	
Medic, black	No		Banvel
Moss	No	Cu So[e]	
Pigweed, prostrate	Some	2,4-D	Banvel
Plantain	No	2,4-D	
Purslane, common	Yes	Banvel	
	Benefin, Dacthal		
Quackgrass	No	No selective chemical	Spot treat with Roundup-dalapon[d]
Shepherdspurse	No	2,4-D (early)	
Sorrel, red	No	Banvel	
Thistle, Canada	No	Banvel	2,4-D
Thistle, musk	No	2,4-D	
Vervain, prostrate	No	2,4-D	
Yarrow	No	Banvel	

[a]Products are listed where superiority has been noted on specific weeds. Follow manufacturer's recommendations on rates.

[b]Follow manufacturer's recommendations on rates. Use wax bars and granular formulations of 2,4-D and Banvel from late spring through early fall to reduce danger of herbicide drift and injury to trees, shrubs and gardens. Banvel injury to susceptible plants can occur by root uptake.

[c]Treat individual plants. Do not spray entire lawn. Dalapon will kill all grasses. Use 1/4 lb per gallon of water.

[e]1 ounce copper sulfate per gallon of water to 200 square feet.

D. COMMONLY FOUND LAWN AND TURF WEEDS

1. Annuals

Summer Annuals

Crabgrass (Digitaria spp.)

Foxtail (Setaria spp.)
- Yellow (S. glauca)
- Green (S. veritis)
- Giant (S. faberili)

Sandbur (Cenchrus spp.)

Bedstraw (Galium spp.)

Common Chickweed (Stellaria media)

Knotweed (Polygonum spp.)
- Prostrate (P. aviculare)
- Erect (P. erectum)

Kochia (Kochia scoparia)

Mallow (Malva spp.)
- Common (M. neglecta)
- Dwarf (M. rotundifolia)

Black Medic (Medicago lupulina)

Pigweed (Amaranthus spp.)
- Prostrate (A. blitoides)
- Redroot (A. retroflexus)

Purslane (Portulaca spp.)
- Common (P. oleraces)

Annual Bluegrass (Poa annua)

Winter Annuals

Common Chickweed (Stellaria media)

Field Pennycress [fanweed] (Thlaspi arvense)

Henbit (Laminum amplexicaule)

Shepherdspurse (Capsella bursa - pastoris)

2. Biennials

Musk Thistle (Carduus natans)
Bull Thistle (Cirsium vulgare)
Salsify (Tragopogon pratensis)

3. Perennials

Smooth Brome (Bromus inermis)

Tall Fescue (Festuca arundinacea)

Quackgrass (Agropyron repens)

Creeping Bellflower (Campanula rapunculoides)

Field Bindweed (Convolvulus arvensis)

Mouseear Chickweed (Cerastium vulgatum)

Dandelion (Taraxacum spp.)

Plantain (Plantago spp.)
Broadleaf (P. major)
Buckhorn (P. lanceolata)

Red Sorrel (Rumex acetosella)

Canada Thistle (Cirsium arvense)

Common Yarrow (Achillea millefolium)

E. HERBICIDE FORMULATIONS

Turfgrass herbicides may be applied either in liquid or solid form. Most preemergent herbicides are used in the solid formulation while many postemergent herbicides are liquid. Soil fumigants are normally injected as a gas followed by sealing the soil to prevent gas escape.

1. Liquids of the hormone type are normally esters or amine salts. Ester formulations may be low-volatile or high-volatile. Low volatile esters release a minimum amount of fumes at temperatures below 85 degrees F., while high volatile esters give off fumes at lower temperatures. Air temperatures can be misleading since temperatures at the lawn surface may be 20 to 40 degrees higher. Salt formulations (lithium and amine) are less hazardous because they do not give off damaging fumes.

Ester formulations are not safe to use around ornamentals because of volatilization or vapor hazards.

Wind movement of spray particles is equal on both esters and salts.

Read labels carefully and select the very safest formulations and products available. Proper use begins with selection of the correct weed killer and a safe formulation.

2. Solid formulations commonly available are granules and wax bars. Both of these formulations provide effective weed control and reduce risk to desirable ornamentals and vegetable gardens.

Granular formulations work most satisfactorily when applied in late evening or early morning, when weed species are damp. Sprinkling with water before application also provides the necessary conditions for granular adherence and effective control.

Follow directions closely when using wax bar formulations. Temperatures above 85 degrees F. can cause excessive application and "scorching" of the lawn grass.

CHAPTER VII

TURFGRASS DISEASE MANAGEMENT

A. FACTORS INFLUENCING PEST PROBLEMS

Disease control in turfgrass includes good cultural practices as well as chemical applications. Turfgrass problems often result from causes other than pests. Be sure to consider these factors when diagnosing and treating turfgrass problems.

1. Fertilization: Both low and high nitrogen conditions can render grasses more susceptible to attack by disease. Knowing how individual turf grasses respond to weather and fertilization is essential in managing certain diseases.

2. Soil type and pH: The number and type of microorganisms present is influenced by soil type and pH. These microorganisms, together with the actual physical/chemical characteristics of the soil, can greatly influence pest prevalence.

3. Thatch: Many insects and disease agents find a favorable environment in a heavy thatch area, whereas the turfgrass itself is adversely affected due to decreased air and water movement through the thatch. Pesticide efficiency may be reduced because of the difficulty for the chemical to penetrate the thatch.

4. Mowing: Dull blades can cause turfgrass injury, leaving the grass susceptible to attack by disease causing agents. The optimum height of mowing differs for different turfgrass varieties.

5. Irrigation: Either overwatering or underwatering can predispose turfgrass to weed and disease problems and can increase damage from other causes. Good surface and sub-surface drainage must be maintained. Air movement in waterlogged soils is severely hindered, and roots will suffer from a lack of oxygen.

6. Weather: Disease problems are particularly affected by weather conditions. Knowing when infection periods are likely to occur is an important part of disease management.

7. Turfgrass variety: The variety of turfgrass selected for a particular site is of utmost importance. Varieties known for resistance to diseases commonly encountered in your area should be chosen. Take into account temperature, mowing height, moisture, and weed competition.

8. Traffic: Excessive traffic can result in damaged turfgrass and soil. This can in turn affect water movement and root development.

9. Air circulation: The adverse effects of too little air movement in the soil have already been mentioned. Air movement across the surface of the turfgrass can have a cooling and drying effect which deters the development of many diseases.

10. Competition: Weeds and roots from trees and shrubs may out-compete turfgrass in some areas for water and nutrients. Such weakened grass is more prone to attack by fungi.

B. DISEASE AGENTS OF TURFGRASS

In Montana the major diseases of turfgrass are caused by fungi, which can cause root rots and foliar diseases.

Stands of diseased grass may look thin and unthrifty or contain streaks of circular patches of dead grass. Some of the more common diseases of turfgrasses are described below.

1. Fungi

a. Brown patch appears as irregularly shaped patches of blighted turfgrass that range in size from a few inches to two feet or larger. At first the patches are purple-green, later fading to a light brown. When the grass is wet, diseased patches frequently show dark, purplish margins, called "smoke rings." Brown patch develops best during long periods of humid, hot weather, thus it is an uncommon problem in Montana. High nitrogen fertilization increases susceptibility to the disease.

b. Dollar spot appears in late spring or early summer when the weather is warm and moist. Bleached or yellow-green blotches about two inches in diameter begin to show up and may later run together to give large damaged areas. A fine, "cobwebby" mycelium may be noticeable when dew is present early in the morning. Dollar spot is most damaging when there is nitrogen deficiency and in areas where turfgrass suffers from moisture stress.

c. Fairy rings are seen as circles or darker green, faster-growing turfgrass ranging from two to several hundred feed in diameter. Rings of mushrooms may appear in moist weather. Fairy rings are caused by fungi which decompose organic matter into breakdown products that stimulate grass growth. The mycelium may become so dense that water is prevented from penetrating the soil, and the grass will begin to die. Mechanical aeration may reduce turf damage from fairy ring fungi.

d. Fusarium blight is characterized by a "frog's eye" pattern, or a ring of browned out grass with a tuft of seemingly healthy grass in the center. Fusarium blight is most severe during dry periods and hot temperatures. Lush grass with an accumulation of one inch or more of thatch is highly susceptible to severe outbreaks. Light, frequent waterings and reduced fertilization will help moderate the infection. The disease has been observed in warm, dry areas of eastern Montana.

e. Helminthosporium causes crown rots and leaf spots, know as melting-out. Spots on the leaves usually begin as small purplish reddish-brown areas about the size of a pinhead. These enlarge to form tan to light brown spots with reddish-brown margins. However, lesion characteristics vary depending upon variety. When the disease is severe, the spots girdle the leaves at the base and cause them to yellow. A severe infection may cause a general fading out of turfgrass. Helminthosporium diseases are most severe during long periods of cool, wet weather. They develop best under high nitrogen fertilization. Under ideal conditions the pathogen moves from leaf lesions into crown tissue, causing plant death.

f. Powdery mildew appears most often in shaded, moist areas that suffer from poor air circulation. Stressed grasses are most susceptible to powdery mildew. The disease usually starts in warm weather, but may continue to weaken and thin the grass until snowfall. Powdery gray to white masses appear on the surfaces of diseased blades. If corrective measures are not taken, the blades will turn yellow and die from suffocation. Bluegrasses seem most susceptible. Improved air circulation and use of resistant grasses in shady areas assist in control.

g. Pythium blights are among the most destructive turfgrass diseases. The disease is first seen as small, irregularly shaped, watersoaked patches 1/2 to 4 inches in diameter. Infected blades become matted together and have a greasy appearance. A cottony growth may be evident early in the morning. Diseased areas may eventually range up to ten feet in diameter. Pythium blights develop best in warm, humid weather. High nitrogen fertilization and poor drainage contribute to the severity of the disease. Pythium blight has not caused significant problems in Montana since temperatures in the high 90±s and nearly 100% R.H. are required for disease development.

h. Rusts originally show up as light yellow flecks on the grass blades. As these spots enlarge, the surfaces of the leaves rupture, and dry reddish-brown pustules

develop. At this stage, the spores readily rub off. The grass first turns light yellow and then rapidly turns tan or light brown as the grass leaves die. Rusts develop best in warm air temperatures when the grass is under stress from lack of water or fertilizer. The disease is less severe on grasses grown under high nitrogen fertilization and certain blue grass strains are less susceptible than others.

i. Pink and gray snow molds are turfgrass diseases that occur in cold weather. Snow cover creates an ideal situation for disease development. For serious snow mold development, the soil needs to remain unfrozen under the snow cover. Snow molds are seen as small patches of tan to light brown grass, two to four inches or larger. Pink snow mold spots usually are smaller than gray snow mold spots. Matted grass blades must be loosened to improve air circulation. Gray snow mold is most common in Montana.

j. Stripe smut is most likely to occur in early spring or late fall. Yellow to dark gray stripes develop along the length of the blade. As the disease progresses, black sooty spore masses are released from the stripes. Infected blades eventually split along the stripes. Moist conditions are normally necessary for development of this disease.

2. Nematodes: Many species of nematodes feed on the roots of turfgrasses and reduce their vigor. Nematode injury may be confused with nutritional problems, insufficient water, compacted soil, or any other factor that restricts root development. Nematodes are not serious turfgrass pests in Montana.

Symptoms of nematode injury include thinning or completely killed areas, pale green to yellow color, excessive wilting, and poor response to fertilization.

The best way to identify nematode problems is with a laboratory analysis of soil and plants. Contact your local county extension service for help in obtaining a proper sample.

C. DISEASE CONTROLS FOR TURFGRASS

Disease-producing agents in turfgrasses can be minimized and in some cases controlled through the use of good management practices. Turfgrass fungicides are available for use as preventive means for controlling certain problems. When an outbreak of a disease agent occurs, apply preventive fungicides immediately. After infection has occurred, use a preventive fungicide to protect against future infection. Timing of protective applications should be based on a knowledge of the

life cycle of the fungus and weather conditions that are best for it's parasitic development.

Preventive use of a fungicide is sometimes warranted when the location has a history of turfgrass disease. The routine use of fungicides can prevent disease outbreaks in turfgrass, but is an expensive and potentially harmful practice. Apply pesticides only when needed.

Montana turfgrass producers are fortunate because conditions conducive for most diseases are seldom found in our dry environment. Occasionally, environmental conditions do favor disease outbreaks and when this occurs, fungicide application may be warranted. Seldom, however, are continuous preventative spray program necessary in Montana.

Additionally, by practicing sound management practices discussed earlier in this segment, growers can also dramatically reduce the potential of disease outbreaks.

D. FUNGICIDES FOR DISEASE CONTROL

Fungicides are divided into two groups: protectants and eradicants. Protectants are applied to the foliage before the disease develops. To be effective they must either persist or be maintained by repeated applications. Eradicant fungicides kill existing pathogens on contact and prevent further growth of the organism. Systemic fungicides can be applied either as a protectant or as an eradicant. This class of fungicide is taken up by the plant (usually through the roots) and remains active for a longer period of time, perhaps 1 to 2 weeks or more. This gives a longer period of protection to the plant. The systemic fungicides are usually more expensive and are only suggested for specific diseases. Use the proper fungicide and follow label directions for best results.

A routine treatment schedule might be one where sprays are applied at regular intervals. The schedule may alternate between contact and systemic fungicides to prevent different diseases expected at a particular time of the year. For a homeowner, one to three applications in the spring of a protectant fungicide to control leaf spot would be adequate. If other diseases appear, such as Fusarium blight and strip smut, follow with 1 to 2 sprays of systemic fungicide as needed for control. Systemic fungicides should be drenched into the soil with at least 1 inch (2.5 cm) of water immediately after application.

The list below contains current information available about fungicides and the diseases they control. These fungicides are not being endorsed, and no criticism is intended for those not contained on the list.

Some Fungicides for Control of Turfgrass Diseases

Diseases Controlled	Common Name
Helminthosporium Leaf Spot (Melting-out) *Helminthosporium* spp.	Chlorothalonil Cycloheximide Cycloheximide + Thiram Dyrene Folpet Mancozeb Maneb Pentachloronitor-benzene (PCNB) Zineb
Fusarium Blight *Fusarium roseum* *Fusarium tricinctum*	Benomyl
Sclerotinia Dollar Spot *Sclerotinia homeocarpa*	Benomyl Chlorothalonil Cycloheximide Cycloheximide + Thiram Dyrene Mancozeb Pentachloronitro benzene (PCNB) Thiram
Stripe Smut *Ustilago striiformis*	Benomyl Pentachloronitro benzene (PCNB)
Rust *Puccinia* spp.	Chlorothalonil Cycloheximide Cycloheximide + Thiram Macozeb Pentachloronitro benzene (PCNB) Zineb
Powdery Mildew *Erysiphe graminis*	Cycloheximide Cycloheximide Thiram Mancozeb
Gray Snow Mold (Typhula Blight) *Typhula* spp.	Dyrene Pentachloronitro benzene (PCNB) Thiram
Pink Snow Mold (*Fusarium* Patch) *Fusarium nival*	Benomyl Cycloheximide + Thiram Mancozeb Pentachloronitro benzene (PCNE) Thiram

Pythium Blight (Greasy spot, Cottony Blight) *Pythium* spp.	Cycloheximide + PCNB
Rhizoctonia Brown Patch *Rhizoctonia solani*	Benomyl Chlorothalonil Chlorothalonil Cycloheximide + PCNB Cycloheximide + Thiram Dyrene Mancozeb Pentachloronitro benzene (PCNB) Thiram

CHAPTER VIII

PESTICIDE APPLICATION AND DISPOSAL

A. APPLICATION EQUIPMENT

Methods of application vary with: the kind of pesticide, the pesticide formulation, the host, the surrounding environment, and the target pest.

Application equipment must be able to deliver a thorough coverage of the correct amount of pesticide to the plant parts which need protection.

Low-pressure, low-volume sprayers or granular applicators can be used for control of ornamental and turf pests. High-pressure hydraulic or air blast sprayers are not often used on ornamentals or turfgrass. They are best utilized for spraying large trees.

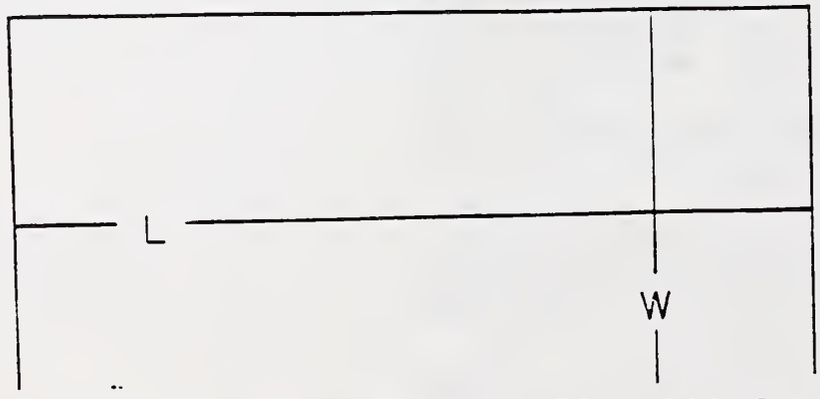
For more specific application equipment information please refer to Montana Department of Agriculture's Basic Equipment Manual.

B. CALIBRATION

Area Measurements

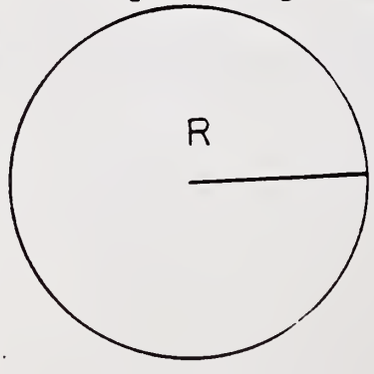
To determine how much pesticide you will need to do a job, you must measure the area to be treated. If the area is a rectangle, circle, or triangle, simple formulas may be used.

Rectangles: The area of a rectangle is found by multiplying the length by the width. Area = Length x Width.



Example: Area to treat measures 50 x 100 feet. 50 x 100 = Area or 5,000 square feet.

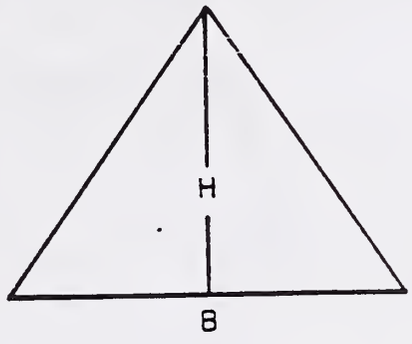
Circles: The area of a circle is the radius (R = one-half the diameter) squared and then multiplied by 3.14. Area = $3.14 \times R^2$.



Example: Area to treat is enclosed by a circular drive. The distance between drives is 80 feet. The radius, or one-half the diameter, is 40. 40 squared (1,600) x 3.14 = Area or 5,024 square feet.

Triangles: The area of a triangle the base (B) multiplied by the height (H) divided by 2.

$$\text{Area} = \frac{B \times H}{2}$$

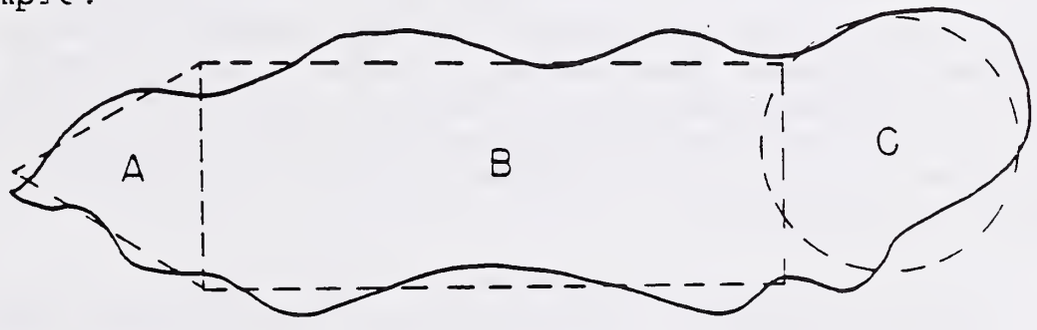


Example: Area to treat is a triangular sideyard extending 50 feet from the house and has a base of 60 feet.

$$\frac{50 \times 60}{2} = \text{Area or } 1{,}500 \text{ square feet.}$$

Irregularly shaped turfgrass areas often can be reduced to one or more of these common shapes. Calculate the area of each and add them together to obtain the total area.

Example:

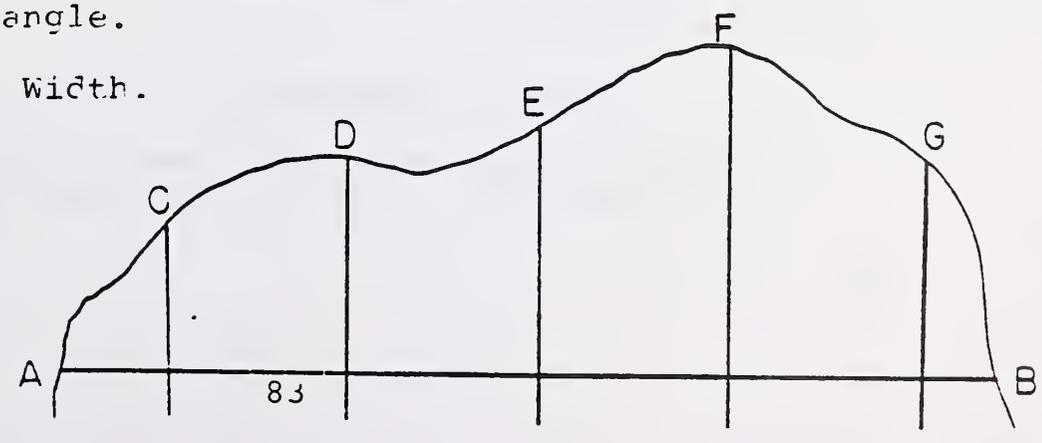


Area A + B + C = Total Area

Another way is to establish a line down the middle of the property for the length, and then measure from side to side at several points along this line. Areas with very irregular shape require more side to side measurements. The average of the side measurements can be used as the width. The area is then calculated as a rectangle.

Area = Length x Width.

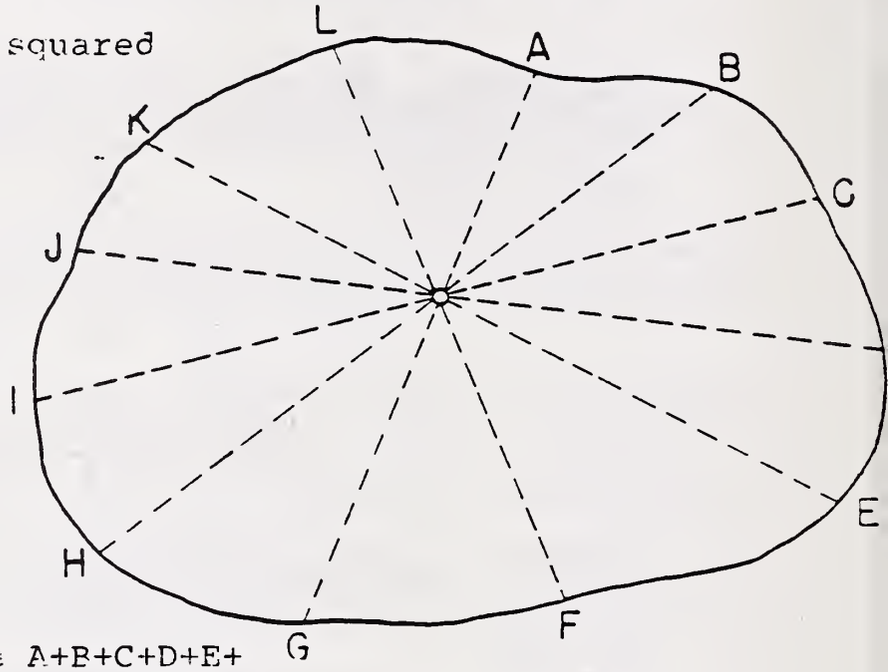
Example:



A third method is to convert the area into a circle. From the center point measure distance to the edge of the area in 10 to 20 increments. Average these measurements to find the average radius. Then calculate the area, using the formula for a circle.

Area = 3.14 x the radius squared

Example:



$$\text{Area} = (3.14) \times \frac{\text{line A+B+C+D+E+ F+G+H+I+J+K+L}}{12}$$

C. DISPOSAL

1. Disposal of Excess Material

The Environmental Protection Agency recommends ways to dispose of excess pesticides. Consult local health offices or the Montana Department of Health and Environmental Sciences, Solid Waste Management Division for procedures in your area. If you have excess organic pesticides you may dispose of them by:

using them up as directed on the label;
burning them in a specially designed pesticide incinerator;
burying them in a specially designated landfill;
storing them in a safe manner until they can be burned or buried.

2. Disposal of Empty Pesticide Containers

Proper disposal of empty pesticide containers includes the following steps:

a. Liquid formulations:

Triple rinse containers immediately after emptying. Add this rinse water to the spray tank.

Puncture the top and bottom of the container to prevent reuse.

Dispose of the container in any licensed sanitary landfill.

Barrels and larger drums may be sent to a reconditioning depot following triple rinse procedures.

b. Dry Formulations:

Completely empty the contents of the container into the tank.

Open both ends of the bag to prevent reuse. Rip or cut the bag carefully - a strong jerk could cause dust to fly up into your face.

Deposit the container in a licensed sanitary landfill.

Containers should not be burned unless the registered label provides such directions and permission is granted by the Montana Department of Health and Environmental Sciences. Burning in most incinerators does not completely break down all pesticides.

Containers may be buried on private property, but care must be taken to avoid accumulations of concentrated pesticides in one area.

CHAPTER IX

DAMAGE ON LANDSCAPE PLANTS

A. DIAGNOSING PLANT PROBLEMS

Plant damage can be caused by many biological or environmental factors. Before considering any pesticide application, the true cause of the problem must be determined.

1. Symptoms Involving the Whole Plant

a. Failure of a recently transplanted plant to grow may be due to drought, excess water, injury prior to planting, or an insufficient root system.

b. Sudden death of a growing plant or plant parts may be caused by disease, an excess of fertilizer, noxious gas, lightning, herbicide injury, or girdling of the plant.

c. Gradual decline of a previously healthy plant, poor growth, yellowing and dropping of foliage, or death of individual shoots may be due to air pollution, construction, disease, drought, excess moisture, excess fertilizer, noxious gas, a grade change, insect injury, poor nutrition, improper soil pH, or girdling of the plant.

2. Symptoms Involving Roots, Main Stem, or Branches

a. Malformations of growth may be caused by insect injury, diseases or herbicide injury.

b. Dieback of shoots may result from insect injury, construction, disease, excess water, girdling of the plant, hail damage, lack of light, poor nutrition, or winter injury.

c. Twigs or shoots with healthy leaves dropping to the ground may be caused by insects or vertebrates such as squirrels.

d. Bark splits on the trunks may result from lightning or winter injury.

e. Pitch on the trunk or main branches may be caused by insect injury.

3. Symptoms Involving the Foliage

a. Yellow or mottled foliage which may be less than average size, distorted, and prematurely dropping may be due to air pollution, disease, excess water, graft incompatibility, improper soil pH, insect injury, or poor nutrition.

b. Curled and distorted foliage may be caused by insect injury, herbicide injury, or disease.

c. Wilted foliage may be the result of disease, drought, excess fertilizer, excess moisture, or a gas leak.

d. Skeletonized leaves or tunnels or mines beneath leaf surfaces are caused by insects.

e. Dark spotting may be caused by disease or spray injury.

f. White leaves or a powdery appearance of the leaves may be the result of air pollution, disease, or herbicide injury.

g. Chewed margins of the leaves are usually caused by insects.

h. Grayish foliage especially on evergreens, may be an indication of air pollution or mite injury. If mites are the cause, webbing may also appear on the foliage.

i. Rolled leaves may be caused by cold temperatures, drought, or leafroller insects.

j. Missing needles may be due to natural needle drop, insect injury, lack of potassium, or disease.

k. Rusty areas on the leaves are caused by disease.

l. Black scoty appearance of leaves and stems is a sign of insect injury.

4. Symptoms Involving the Flowers

a. Failure to produce flowers may be due to improper photoperiod length, improper pruning, juvenility, nutrient imbalance, winter injury, or excess shade.

b. Failure to open properly may be caused by drought, insect injury, spray injury, winter injury, or disease.

c. Chewed petals usually are an indication of insect damage.

d. Short flowering period may be caused by drought or unusually high temperatures and low humidity.

e. Splitting of flower buds may be due to herbicide injury, excess moisture, or improper temperatures.

B. NON-PEST INJURY

1. Pre-Transplant Injury

When a recently transplanted plant fails to grow and the cause cannot be associated with drought, excess moisture, or insufficient roots, it is possible that the plant might have been injured prior to planting. It might have dehydrated while in storage or in transit, or it might have been subjected to an excessively high temperature.

2. Insufficient Root System

Plants that have been recently transplanted may not have a large enough root system to support the crown of the plant. Therefore, it is desirable to prune the crown of trees and shrubs that have been transplanted to help reduce the amount of transpiration during the reestablishment period. When pruning trees, do not cut the central leader, rather, thin cut and help shape the tree or shrub in its natural form.

Sometimes trees are dug with a root system that is completely inadequate for the size of the plant. Such plants should not be accepted for planting. Industry standards have been established to assist in determining proper root ball diameter.

3. Change in Grade

A change in level of the soil or some type of construction work in the vicinity of plants will change the soil environment which for some species of plants can result in their decline and eventual death. A few inches of clay fill over the roots of a beech tree or dogwood can be disastrous. Disturbing the roots of hard maples will often result in their showing early fall color and eventually the death of branches followed by death of the trees. Plants showing damage on one side may have had pipeline trenching disturb the roots on the affected side.

4. Soil pH

In order to make good growth, plants should be grown in soil with an optimum pH (soil reaction). Most plants grow well in a pH range of 5.5 to 7.5. However, some plants such as blueberry and rhododendron require acid soil (pH 4.5 to 5.5). Other trees, like the pin oak and holly, will develop iron chlorosis when grown in alkaline soils (pH 7.5 to 8.5). Red and silver maple will exhibit manganese chlorosis in similar sites.

5. Malnutrition

Plants require certain elements which are essential for growth and proper development. A minimum supply of a particular element can cause the plant to be stunted, have yellow, mottled or scorched foliage and if completely lacking can result in the death of branches. Three of the more common deficiencies associated with ornamental plants are:

a. Nitrogen causes yellowing of the foliage. Although the entire plant may show the symptom, it will be expressed in the oldest leaves first.

b. Potassium is first expressed along the margins of the older leaves, which will become scorched. Older foliage will drop prematurely producing a leggy appearance.

c. Iron chlorosis is commonly associated with plants growing in soil with a pH above the optimum for that species. The symptom is a yellowing of the tissue between the veins while the tissue adjacent to the veins remains green.

Soil tests can be used to determine the levels and balance of the mineral elements in your soil. Application of the appropriate fertilizer can correct the deficiency. However, it should be recognized that similar symptoms may result from other causes and that fertilizer is not a panacea for all the ills of plants.

6. Excess Soluble Salts

Too much fertilizer, especially soluble forms, can cause problems in the growth and development of plants. Plants growing in containers (pots or plants boxes) without drainage holes can become the victims of a buildup of salt within the container. Plants exposed to either of these conditions will dehydrate. The rapidity of dehydration will depend upon the concentration of salt. The condition will develop slowly in containers unless fertilizer was applied, in which case the desiccation will be as rapid and injurious as when too much fertilizer is applied to plants in the garden. Always follow instructions when using fertilizer on plants, and avoid growing plants in containers without drainage holes. If too much fertilizer has been applied, it might be leached out of the root zone by applying liberal quantities of water to the soil. Soluble salt problems can be confirmed by making a conductivity test with the aid of a solu-bridge on a sample of soil.

7. Lack of Water

All plants require some water and most plants required large quantities if they are going to grow in a normal manner. Although most plants receive adequate moisture as a result of rainfall or by artificial means, there are times when plants can dehydrate: 1) following transplanting; 2) left growing in containers or 3) planting in adverse sites in a landscape (such as under building overhang). Following transplanting, plants should be watered periodically until well established. Plants in containers and in adverse sites should be watered on a schedule to assure adequate supplies of water for their growth. Be sure to remove plastic burlap commonly used to wrap root balls of plants.

8. Excess Water

Too much water roots of most plants used in the landscape can result in their decline and ultimately in their death. Plants require some oxygen in the soil for good growth and development. Planting sites should be well-drained or measures taken to artificially drain the site prior to planting. Drainage systems must be connected to free flowing drains to be effective. Often plants are placed in a shallow depression hollowed in heavy clay soil. These conditions allow little or no drainage even if rocks or gravel are placed in the bottom of a planting hole. Do not cover soil surface of planting sites with plastic if the soil is a clay or clay loam and is subjected to excess rainfall, runoff water, or irrigation,

9. Weather

The forces of nature can produce some dramatic forms of injury to plants. However, they can also produce injury which is more subtle and more difficult to identify as to possible cause.

a. Although not too common, lightning injury can be the most dramatic form of injury. Most trees struck by lightning, but not all, will have large areas of wood exposed with bark hanging in shreds. However, at times there may be no visible symptoms and the diagnosis may have to be made on circumstantial evidence, such as: was there a recent lightning storm and is it probable that the tree might have been struck? Trees struck by lightning may die within a few days, live for a number of years and then die, or survive the strike and live to an old age. However, trees with exposed wood should be treated by an arborist.

b. Snow that is wet and piles up on the branches of plants can cause damage in the form of breakage. A more subtle form of injury can result to broadleaved

evergreens (e.g. boxwood) which are bent to the ground as a result of snow, recover in the spring but commence to die the following year. This delayed symptom is the result of physical damage done to the bark of the branches while under stress from snow. It can be prevented by providing some means of physical support prior to the onset of winter.

c. Hail causes physical injury to leaves and stems. In some cases, branches injured by hail may die. Damage is usually limited to the side from which the storm carrying hail approached.

d. Winter environment especially late winter, can cause problems to many plants, including freezing injury to buds and shoots, desiccation of evergreen foliage, and cracking of stems. Some evergreens, (especially broadleaved evergreens) when exposed to the direct rays of the sun of late winter while the ground is still frozen, will winterburn due to the lack of moisture or from extreme temperature changes.

e. Wind can sometimes cause serious problems to plants, particularly when it carries sand that abrades the stem, commonly at the groundline. This form of injury can be prevented by maintaining a cover crop on the ground to stabilize the sand.

f. High temperatures will often result in a short flowering period and, if moisture is in limited supply, will contribute to leaf scorch. Fire will scorch foliage and can destroy the cambium which will result in the death of plants.

10. Chemical Injury

Various types of chemicals applied to or drifting onto plants can cause injury or their ultimate death.

a. Air pollution in industrial or large urban areas can cause damage to sensitive species. In such a situation, the problem is widespread and not limited to a single yard but will cover a larger geographical area. Avoid planting sensitive species but, better yet, act to clean up the air. Pollutants such as ozone and sulfur dioxide have characteristic injury patterns which differ for plant species.

b. Gas leaks can cause either rapid or slow death of plants. If trees and shrubs have been growing vigorously for a number of years and then suddenly decline in vigor, even die within a matter of days, consider the possibility of gas injury to the plants if they are within 100 feet of a gas line. The gas

company can check the area with a gas detection meter. However, before calling the gas company, check for girdling roots or other causes of the decline.

c. Animal urine can be toxic to lawns and ornamental plants. Female dog urine can cause circular dead spots in the lawn and the urine of male dogs can cause unsightly brown areas on the lower portion of valuable evergreens. Cats confined to a small area can cause plants to decline due to the excess salt problems which develops in the site where they urinate. Various repellants are available that are supposed to discourage visits by stray dogs. However, repeat applications are necessary.

d. For years, tree roots have been a problem to the proper functioning of drain fields. More recently, drain field effluent has been causing problems to trees. Borax and chemical agents used in laundry and cleaning products are leached into the soil where they cause injury to plants growing in close proximity to the drain.

e. Applying the wrong chemical or improperly applying a pesticide can cause injury to plants. The most common form of spray injury is leaf burn, particularly detected on the margins or tip of the leaf. The propellant in aerosol sprays or the emulsifying agent can be responsible for injury to some plants. Dormant oils applied at the wrong time of the year or to sensitive species can also be responsible for plant injury.

f. If the new growth of plants is malformed and the leaves cupped and chlorotic (yellow or white), it is possible that a herbicide such as 2,4-D or dicamba has been applied in the vicinity of the plants. Some weed and feed lawn fertilizers contain dicamba, an excellent weed killer, but it should not be applied within the root zone of valuable trees and shrubs. Spray application of 2,4-D type weed killers should be made only on calm days as certain formulations may drift onto valuable plants and cause various malformations of growth. Nonselective herbicides should be used with caution as they may wash into areas where they could kill valuable landscape plants. Spray equipment used to apply weed killers should not be used for other purposes.

g. Drift from highways following the application of deicing salts in winter can cause serious injury to sensitive plant species (e.g., white pine, red pine, red oak, or crab apple).

11. Vertebrate Animals

Animals of all kinds can cause considerable damage to plants. Girdling of the stems of plants by certain rodents is common, especially following severe winter weather. In addition, rabbits can decapitate or chew the bark of young plants. Deer will eat the foliage, bark and tender shoots of plants. Other large animals can damage trees by clawing or rubbing the bark off tree trunks, chewing the foliage, compacting the soil (when confined to a small area) and by physically breaking the plants.

Much of this type of injury can be prevented by fencing out the animals or by applying various repellants to young plants, especially prior to the onset of winter.

12. Girdling

a. A decline in vigor may be due to the girdling action of a wire or nylon rope encircling the stem, or to the action of girdling roots or vines. Nondeteriorating ropes used to secure the ball of soil during transplanting, and guywires that supported newly planted trees should be removed when no longer needed. At the time of plantings, be sure that the roots are properly distributed in the planting site and that there are no encircling roots on plants that were produced in containers.

b. Most rodent damage is done during winter months when they are short of their natural food supply. This form of damage can be minimized by the careful use of rodenticides and keeping the area clear of weeds.

c. Mechanical injury and many of the activities of man can also result in girdling valuable plants. Injury caused by mowers has increased considerably with the use of riding mowers. Cultivator or hoeing injury will often cause young plants to die. Employees should be instructed to direct contact.

d. Although delayed graft incompatibility is not a girdling action, this is somewhat similar in end results. The union of some grafted or budded plants fails to function and the plants die. Very often this is preceded by a massive floral display or early fall color. Inarching (grafting) can sometimes be used to repair a tree. Normally when the condition is noted, it is too late to inarch.

1. Oystershell scales
   (sucking mouthparts)
   page 20

2. Spittlebug adult
   (sucking mouthparts)
   page 16

3. Conifer sawfly larva
   (chewing mouthparts)
   page 10

4. Conifer sawfly larva
   (chewing mouthparts)
   page 10

5. Carpenterworm-moth larva
   (chewing mouthparts)
   page 25

6. June beetle - adult grub
   (chewing mouthparts)
   page 58

Photos courtesy of National Agriculture Library USDA Forest Service

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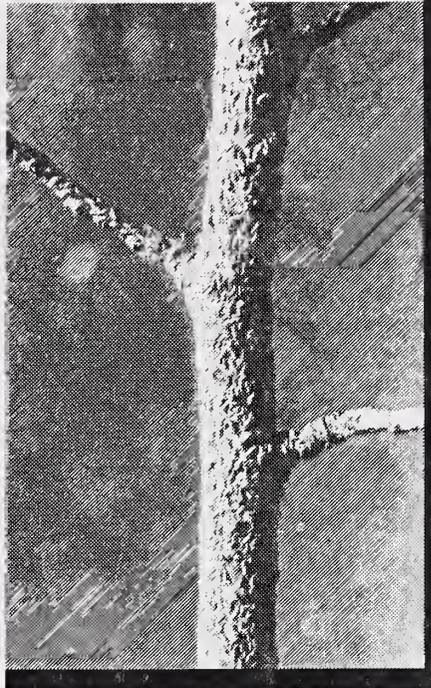

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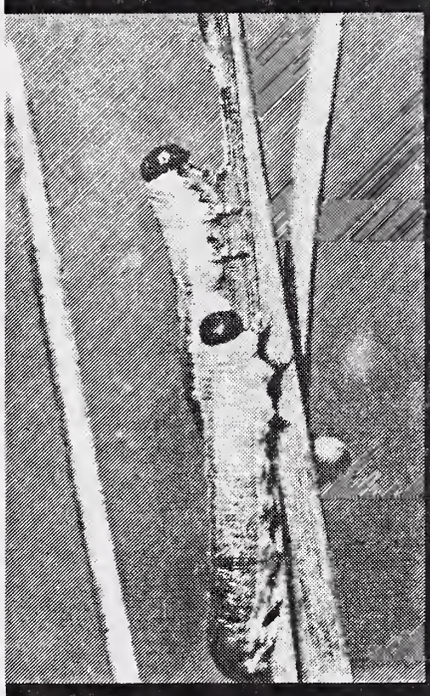

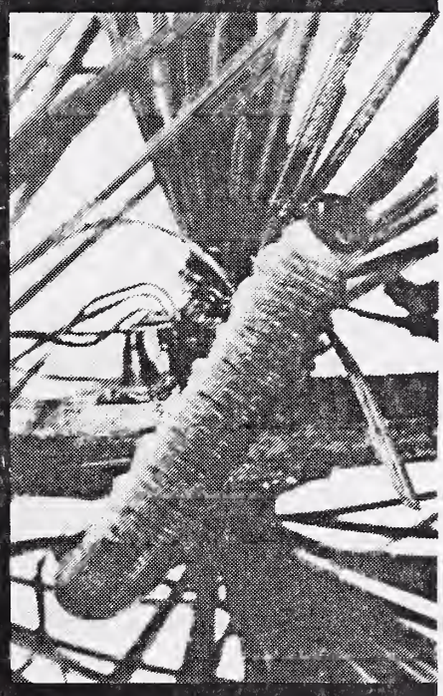

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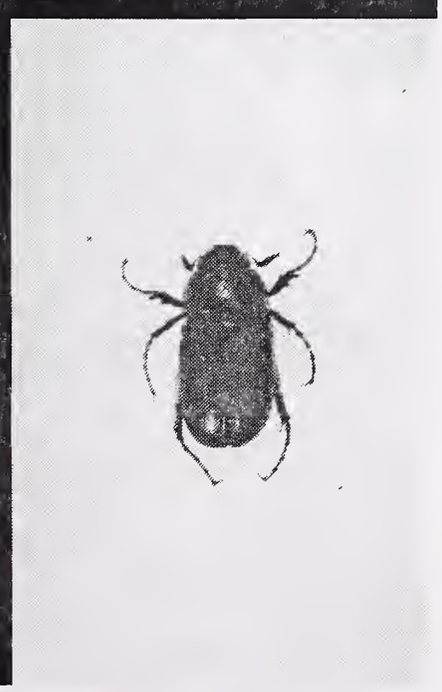


6.

7. Banded alder borer - larva
roundheaded wood borer
(chewing mouthparts)

8. Mountain pine beetle
egg-larva-pupa-adult
(chewing mouthparts)
page 26

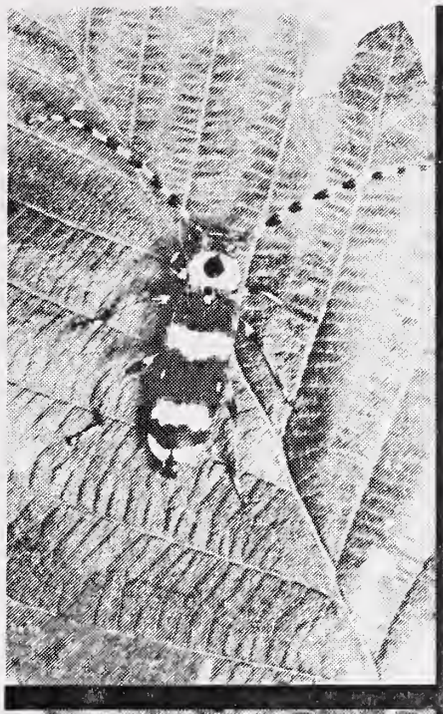
9. Western tent caterpillar -
moth larva
(chewing mouthparts)

10. Larvae & tent of western
tent caterpillar

11. Forest tent caterpillar -
moth larva
page 7

12. Cocoon containing pupa
of western tent caterpillar
page 7

Photos courtesy of National Agriculture Library USDA Forest Service



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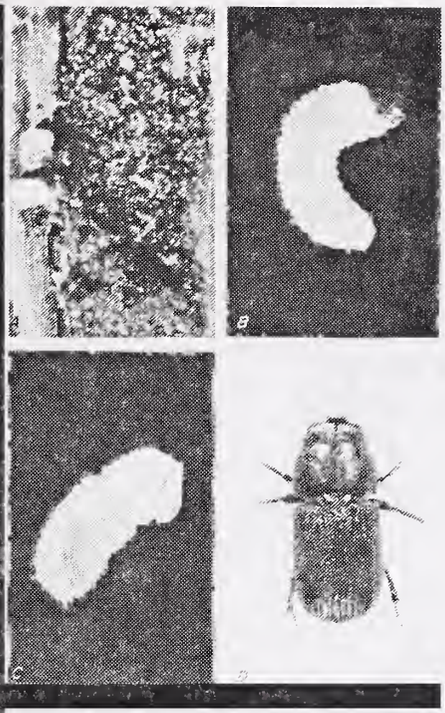

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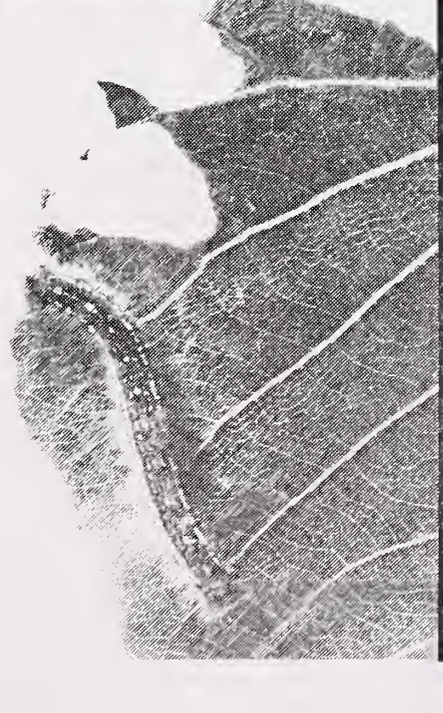

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12.

ORNAMENTAL INSECT PEST DAMAGE

External Feeding Damage

13. Whole Leaf Feeder
page 5

14. Skeletonizer
page 12

15. Leafroller & Tier
page 11

16. Leafminer
page 20

INTERNAL FEEDING DAMAGE

Gall Insects

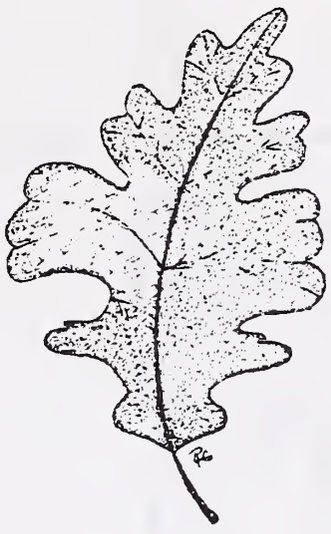
17. Poplar Petiole Gall
page 23

18. Hackberry Nipple Gall
page 23

Boring Insect

19. Carpenterworm
page 25

13.



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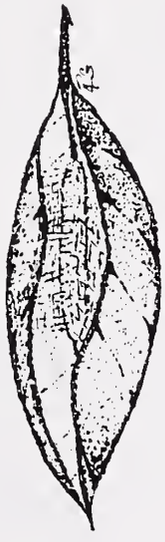

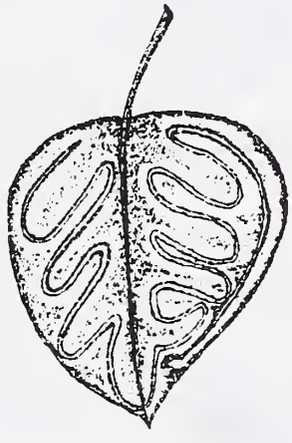

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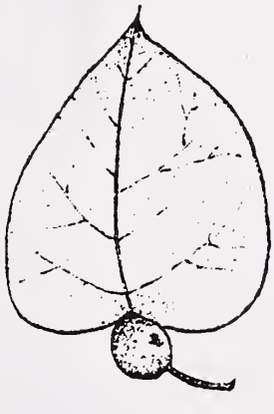
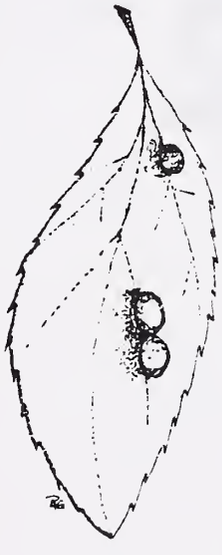




18.

19.

SOME ORNAMENTAL INSECT PEST

Chewing Insects

20. Grasshopper
page 5

21. Earwig
page 6

Sucking Insects

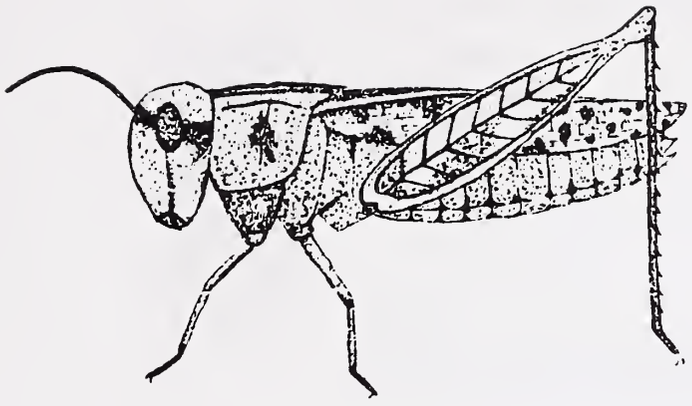
22. Froghopper
page 16

23. Leafhopper
page 16

24. Treehopper

25. Mealybug
page 19

26. Psyllid (jumping plantlice)
page 17



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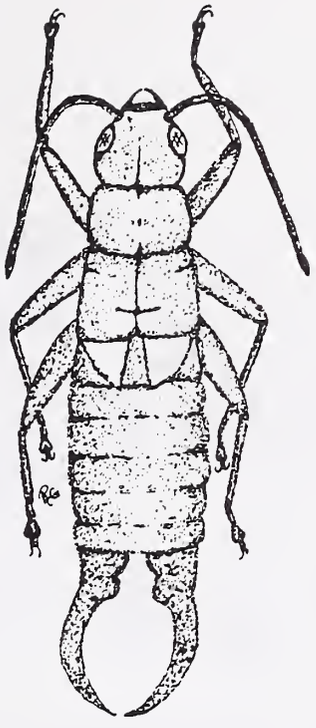

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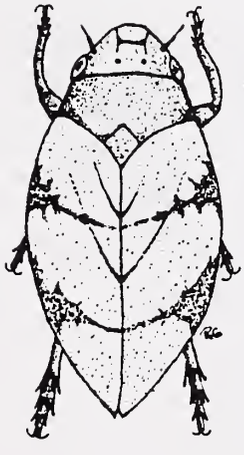

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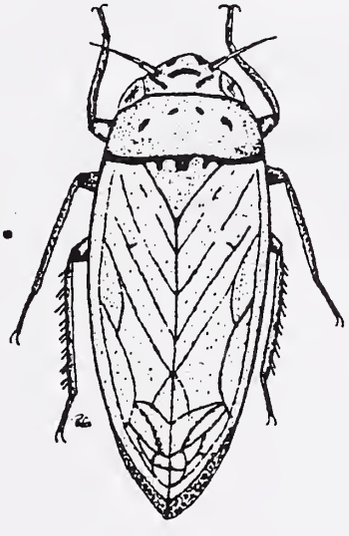

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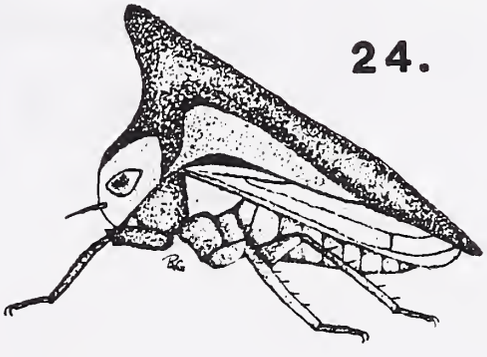

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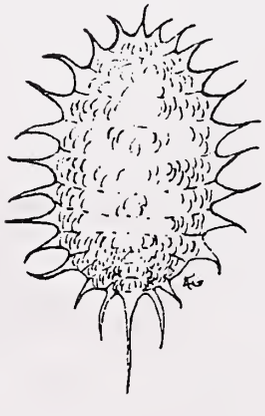
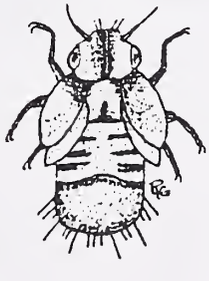




26.

TURF INSECT PEST

Soil Inhabiting Insects

27. Billbug (adult-larva)
    page 59

28. Grub (adult-larva)
    page 58

Thatch Inhabiting Insects

29. Chinchbug (adult-nymph)
    page 62

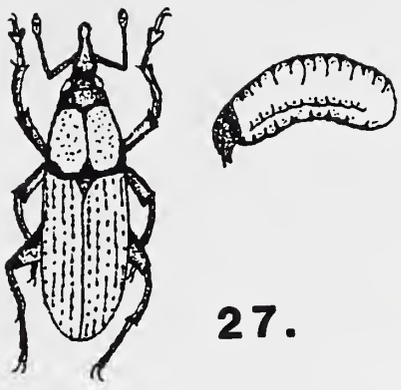
30. Sod webworm (adult-larva)
    page 60

Sampling

31. Roll back turf to inspect for soil inhabiting insects

32. Water flotation for chinchbugs

33. Irritant for sod webworm



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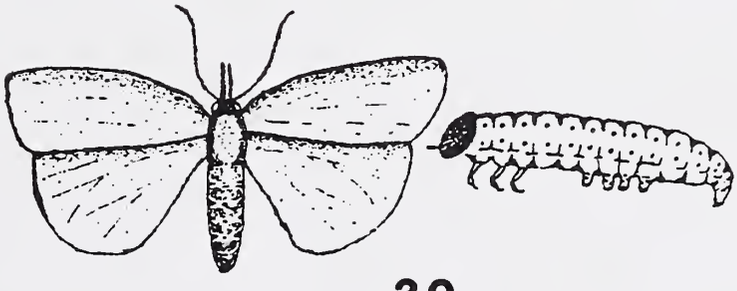

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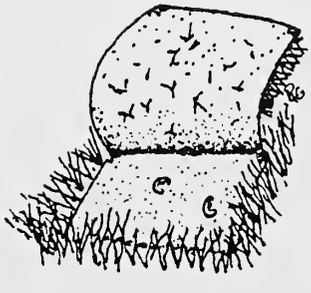

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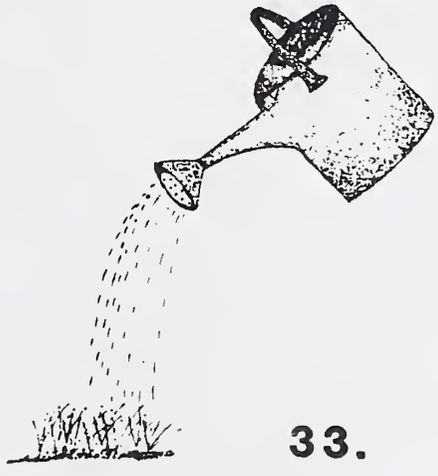

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